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WISCONSIN GEOLOGICAL AND NATURAL HISTORY SURVEY
E. A. BIRGE, Director. W. O. HOTCHKISS, State Geologist.

BULLETIN NO. XXIII. ECONOMIC SERIES NO. 14

RECONNOISSANCE

SOIL SURVEY

OF

PART OF

NORTH WESTERN WISCONSIN

BY
SAMUEL WEIDMAN

ASSISTED BY
E. B. HALL AND F. L. MUSBACK

MADISON, WIS.
PUBLISHED BY THE STATE
1911

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PREFACE.

The following general reconnoissance soil survey of nine counties in the northwestern part of Wisconsin is presented in response to numerous requests for information concerning the character of the soils and agriculture of the northern part of the state. This report is the result of a survey of the geological formations of the area combined with a special study of the principal types of soil developed upon these formations. The various surface formations of glacial drift, loess, and alluvial deposits, and the indurated formations of granite, sandstone, and limestone have characteristic soil types developed upon them, and these various soil types are described with respect to area, surface features, forest growth, character of the soils and their agricultural development.

Chapter I, a general description of the geology and geography of the area, and Chapter III, the description of the soils and their agriculture, are based almost entirely on original investigations; while Chapter II, on climate, and Chapter IV, on the general agricultural development in the area are mainly compiled from various sources, as indicated.

Some of the counties in the northern part of the area are still largely unopened to agriculture, while others, in the southern part, are fairly well settled. Large portions of the area, as described in following pages, are covered with hardwood forests, possess excellent soils, and are rich in agricultural possibilities. Some parts of the area also are characterized by soils of inferior quality. It is the purpose of this general report to point out the general character of the soils and the climatic and general agricultural conditions throughout the area, with the hope that the information given and the

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suggestions offered will be of value not only to home seekers, but also to those now engaged in agriculture in the district.

Since the soil survey of this area was begun, provision has been made for a complete and more detailed soil survey of the entire state, and this work, now in progress in other parts of the state, is being executed by the State Survey in cooperation with the Bureau of Soils of the U. S. Department of Agriculture. It is the general intention under the present plans of the soil survey, that the soils of the thickly settled counties of this area will be given a detailed study at some future time, probably as soon as the surveys of the counties of the southern part of the state are completed. In the meantime the reconnoissance soil survey of this area is presented, the authors being fully aware of its incompleteness, with the hope that it will prove to be useful to the many interested in the agricultural development of this part of the state, and that the general study of the soils described will serve as a basis for a more detailed survey of this district at some later date.

I have been assisted in the preparation of this report by E. B. Hall and F. L. Musback. Mr. Hall, of the Geological Survey, mainly assisted in the preparation of the soil map, and Mr. Musback, of the Soil Survey, assisted in the collection of soil samples and agricultural data.

The State Survey is indebteded to the U. S. Bureau of Soils for kindly furnishing the mechanical analyses of soils in this report; the authors are indebted to Dr. E. A. Birge, Director of the Wisconsin Survey, for the many courtesies shown in the preparation of this work, to Prof. A. R. Whitson, in charge of the Soil Survey, for suggestions and criticism, and to Dr. J. C. Elsom for the several photographic views presented.

S. WEIDMAN.

July, 1911.

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RECONNOISSANCE SOIL SURVEY OF NORTH WESTERN WISCONSIN.

CHAPTER I.

GENERAL DESCRIPTION OF THE AREA.

The area described in the present report is in the northwestern part of the state, as shown on the map of Wisconsin, fig. 1. Four of the counties border on the state of Minnesota on the west. It is approximately between the parallels 44° 30′ and 45° 45′ north latitude, and the meridians 91° and 93° west longitude, which is the same latitude as central Maine on the Atlantic coast, and northern Oregon on the Pacific, and the same longitude as central Louisiana, Arkansas, and Missouri in the Mississippi valley.

The area includes the counties of Eau Claire, Chippewa, Rusk, Barron, Dunn, Pepin, Pierce, St. Croix, and Polk. These nine counties contain 186 townships and have a total area of 6,705 square miles, approximately one-eighth of the state.

. *Slope and General Features.* The area slopes down towards the southwest. The lowest land, 680 feet above sea level, is in the southwest corner of the area at the junction of the Chippewa and Mississippi rivers. The highest land is undetermined but is very probably the hard quartzite ridges of eastern Barron and western Rusk counties. Several of these ridges reach elevations of 1,500 to 1,600 feet above sea level, the lower land surrounding these highest ridges in the northern part of the area in general, having a varying altitude between 1,100 to 1,300 feet.

The western part of the area, Pierce and St. Croix counties, are mainly limestone uplands, in which the valleys are relatively

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deep and narrow. A large part of Polk and Rusk counties is a nearly level plain, with broad shallow valleys.

FIG. 1.—Map showing the location of the North Western and North Central Wisconsin areas.

The principal topographic feature of the area is the relatively level or gently sloping surface of the land. Like other parts of the Mississippi valley it is an undulating plain into which valleys have been cut by the rivers and streams.

Upon the broad uplands of much of the area also are extensive deposits of glacial drift which in many places still retain the general forms left by the great ice sheets that have invaded this region. The beautiful lakes in the region are also intimately related in origin to the glacial deposits. Besides the glacial deposits there are extensive wind deposits of loess over large portions of the uplands of the area. In many of the valleys

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are thick deposits of loose sand and gravel which assume the forms of terraces.

Geology.

The formations of the area may be grouped into two divisions and six sub-divisions, as follows:

Indurated Formations:

1. Crystalline rocks.
2. Sandstone.
3. Limestone.

Surface Formations:

4. Glacial drift.
5. Alluvial or river deposits.
6. Loess.

A generalized map showing the indurated or bed-rock formations is presented in Plate II. A cross section showing the relations of the formations is shown in figure 2.

1. Crystalline Rocks. This group, mainly of Pre-Cambrian age, includes several kinds of rock, such as granite, quartzite and trap rock. The granite rocks which include light colored schists, gneiss and granite and dark colored coarse and fine grained diorites, are found mainly along the Chippewa river and its tributaries above Eau Claire. Many wells reach the granitic rocks in northern Chippewa and in Rusk counties. The quartzite forms the high hills and ridges in eastern Barron and in western Rusk counties. Flambeau Ridge is also quartzite. The trap-rocks (Keweenawan) occur in the vicinity north of Osceola and at St. Croix Falls and extend in a belt farther northeast across the central part of Polk county, to Clam Falls.

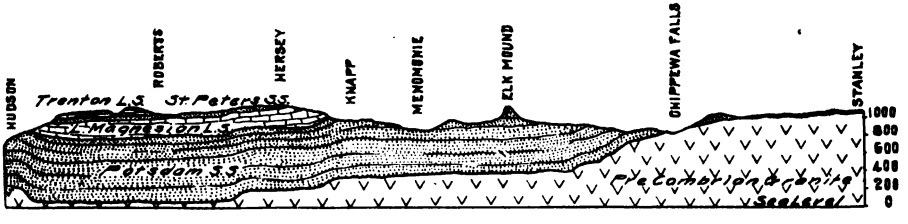

Fig. 2.—Section showing geological formations.

Origin of the Crystalline Rocks. Most of the crystalline rocks, such as the granite and trap rocks, are of igneous origin, and were brought to the surface from the interior in a heated molten

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condition. The quartzite, however, was originally a sandstone, and was metamorphosed into quartzite by the great heat developed by the intrusive igneous rocks. None of the crystalline rocks contain fossils.

2. Sandstone. The Potsdam sandstone (Middle Cambrian) formation is the prevailing surface rock in Eau Claire, southern and western Chippewa, southern Barron, Dunn, and eastern Pepin counties. It lies beneath the drift in parts of Rusk, northern Barron and Polk, and is exposed along the bottoms and side of the valleys. The Potsdam sandstone lies in horizontal beds upon the crystalline formations, a fact to be noted in all cases where the two formations are exposed together or where wells penetrate both. The sandstone is quite generally a soft friable stone. In many places, the formation contains beds of shale rock, and green-sand. The fine sandstone weathers into a sandy soil but where shale and green-sand occur, loams are developed. Where the sandstone is overlain with glacial drift, the soil has the loamy character of the drift covering.

Origin of Sandstone. The sandstone is a form of sedimentary rock deposited in shallow water of the sea. Common fossils in the Potsdam sandstone are the shells or casts of trilobites, a kind of crustacea, and of small brachiopods, a kind of bivalve.

In Pierce and St. Croix counties, in the area of the limestone, is the thin formation of St. Peter sandstone (Ordovician). The St. Peter sandstone overlies the Lower Magnesian limestone and while it does not form many outcrops it has modified the soil conditions to a considerable extent in many places in these two counties.

3. Limestone. The limestone, mainly the Lower Magnesian formation (upper Cambrian), forms the main bed rock in western Dunn and western Pepin counties, and over the entire area of Pierce and St. Croix counties. The limestone also forms the summits of many of the uplands in eastern Pepin and southwestern Eau Claire. It extends as far north as southern Polk county where it is generally overlain, however, with thick drift, and is exposed only along the rivers.

In western Pierce and southwestern St. Croix counties are numerous high uplands and ridges capped with Trenton limestone (Ordovician). The soils developed on the limestones are generally loams and consist of a modification of local limestone

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soil with the surface formations of glacial drift and loess that covers the general area of limestone in this district.

Origin of the limestone. The limestone is a sedimentary rock, mainly of organic origin, being formed generally from the accumulation of lime-bearing shells and skeletons of sea organisms, more or less broken up into fragments by waves of shallow water. Common fossils in the Lower Magnesian limestone are the articulated invertebrates, both the straight and curved forms, and also abundant corals. The Trenton limestone often contains abundant fossil shells or casts of bivalves, crustacea and coral.

4. Glacial Drift. The glacial drift (Pleistocene) consists of a mixture of ground-up rock containing varying proportions of clay, sand, gravel, and boulders Pl. III, fig. 1. The drift varies in thickness and was deposited upon the older bed rocks of the area by successive ice sheets that invaded this area and the adjacent portions of Wisconsin and northern United States. Between the periods of glacial invasions long interglacial periods occurred, and hence there is considerable difference in the age of the several drift sheets that are found in the area.

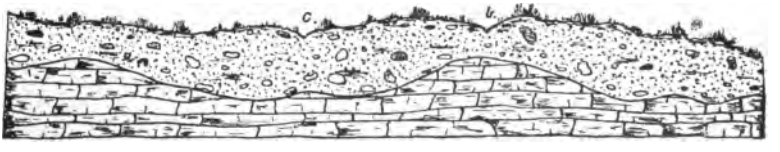

FIG. 3.—Diagrammatic section showing thick drift over rock.

There are some striking differences between the earlier and the later drift formations. Through the action of weathering processes, such as the work of frost, the seepage of groundwater, and the chemical alterations of rocks and minerals the earlier drifts have become more compact and consolidated and contain more clay and fewer boulders than the later drifts. Another important difference between the old and new drifts is in the surface or topographic features. The older deposits of drift have been subjected to a longer period of erosion than the later drift and for this reason the older drift has acquired long drainage slopes and prominent river valleys, while the newer drift subjected to a short period of erosion, is still characterized by belts of steep drift hills and ridges, bouldery "hogsback" ridges, swamps, and lakes. The soil condition of

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the old and new drifts, therefore, are unlike in several important respects.

FIG. 4.—Diaggrammatic section showing thin drift over the underlying rock.

The old drift is abundant in southern Chippewa county and in a belt of considerable width extending from southern Barron county southwest through eastern St. Croix and over most of Pierce county. While the old drift also occurs over most of Dunn and Eau Claire counties and in western Chippewa and southeastern Barron counties it occurs only in relatively small quantity and is not important from the standpoint of the soils.

The area of the new drift is in the northeastern half of Chippewa county, the whole of Rusk, the eastern part and the northwestern part of Barron, the whole of Polk and the northwestern half of St. Croix. The new drift area is characterized by terminal moraines, lakes, and swamps.

5. Alluvial Deposits. The alluvial deposits made by the rivers of the area consist mainly of gravel and sand and form level tracts of variable width in the valleys. Some time during the past, between the periods of the formation of the earliest and the latest glacial deposits, there was a time of extensive valley filling in the area and adjacent parts of the state, presumably caused by a general depression of the land. The rivers and streams were unable to carry away the land wash brought down from the upland slopes and were forced to deposit large amounts of gravel and sand along their courses. In this manner, broad sand and gravelly plains were built up along the Mississippi, the Chippewa, the Red Cedar, the Eau Claire, and other rivers of the area. The alluvial plains cover large parts of Eau Claire, southern Chippewa, Barron, Dunn, and Pepin counties. Alluvial formations occur in the other counties also but are not extensive.

Alluvial Terraces. After filling its valley with waste for a time, a river may change its action and entrench its course in the built-up flood plain. The part of the plain remaining above the new valley floor is called a terrace, or alluvial terrace.

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Fig. 1. TYPICAL SECTION OF GLACIAL SOIL.
Shows eighteen feet of glacial drift consisting of sand, clay and boulders, at Osceola, Polk County.

Fig. 2. TYPICAL SECTION OF LOESS SOIL.
Section shows ten feet of loess, characteristic of the lower slopes of valleys, near Menomonie, Dunn County.

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The Chippewa valley below Chippewa Falls is characterized by a well defined system of five terraces which are especially well developed in the vicinity of Eau Claire. A cross section showing the terraces is illustrated in Figure 5. Well defined terraces are also developed along the Mississippi river and also along the St. Croix and Red Cedar.

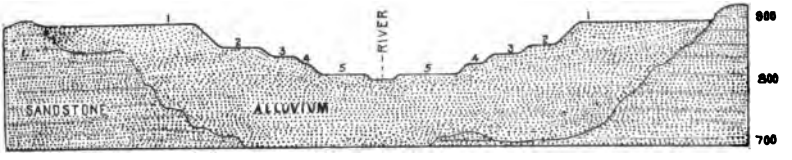

FIG. 5.—Section showing terraces in the Chippewa Valley below Eau Claire.

6. The Loess. The loess consists of fine loam or silt which overlies the bed rock and the glacial drift of considerable portions of the area. It is usually from one to five feet thick and is found mainly on the uplands and slopes and occasionally in the valley bottoms. A view of the loess is shown n Pl. III, fig. 2. The counties in which the loess is an abundant surface formation are Eau Claire, Chippewa, Dunn, Pierce, and Pepin. The loess is mainly restricted to the areas occupied by the older drift formations and to that part of the area in eastern Pepin and western Eau Claire which is entirely free from drift. The loess very probably mainly owes its origin to the action of wind in recent geologic time, probably during the time of one of the later glacial stages.

The loess is free from stone or any other rock material too large to be transported by wind action. It is essentially of uniform character and forms one of the most fertile soil types of the area.

GEOGRAPHY.

The various geographic forms of the land, the valleys, the hills and the plains are the results of the work of the rains and the rivers, the glaciers and the wind, acting throughout a long period of time. In some parts of this area the work of the glaciers and the wind is not important but in most parts of the area these influences were very important in shaping certain forms of the land. In all parts of the area, however, the work of the rain in its course down the land slopes, and of the rivers

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and streams flowing through the valleys, were of great importance in shaping the land features.

Hills. The area contains but few hills that reach an elevation exceeding 200 or 300 feet above the adjacent valleys. The highest hill in the area is Flambeau Ridge in northern Chippewa county, which reaches 400 to 500 feet above the adjacent valley of the Chippewa and Flambeau rivers. Other notable high hills are the ridges of quartzite trending northeast and southwest in eastern Barron and western Rusk counties. In Polk county are ridges and broad uplands of trap rock trending in a northeast direction. Elk Mound is a prominent hill of sandstone capped with limestone in eastern Dunn county. Along the Lower Chippewa, the Red Cedar, the Mississippi and the St. Croix rivers there are steep mounds and valley slopes rising abruptly to heights of 200 to 500 feet above the adjacent rivers.

Origin of hills and ridges.—The hills and ridges of the area were carved into their present reliefs by the erosive work of the rains and the streams. Two types or ages of hills and ridges may be distinguished in the area: One type was formed at an early geologic period out of the crystalline rocks, and the other type was formed at a much later period out of the sandstone and limestone formations. Such ridges as Flambeau Ridge of northern Chippewa county and the high quartzite ridges of eastern Barron and western Rusk counties and the high ridges of Polk county were formed as hills before the age of the Potsdam sandstone. They were subsequently buried under the deposits of sandstone, and in the later period of denudation of the land were uncovered again by erosion. They are in reality fossil hills, like the Baraboo Ridges, and are the remnants of old Archean mountains, the oldest hills on the continent. The other type of hills consisting of sandstone or limestone, like Elk Mound, and like Mt. Tom and Mt. Simon at Eau Claire, and other mounds in the western part of the area, were formed during the present period of erosion, contemporaneous with the denudation of the old crystalline hills.

Terminal Moraine.—A prominent feature of the topography is the belt of boulder ridges and drift hills forming the terminal moraine of the latest ice sheet that invaded the region. This belt of terminal moraine consists of billowy hills associated with swamps and lakes, and has a usual width of 2 to 6 miles. These

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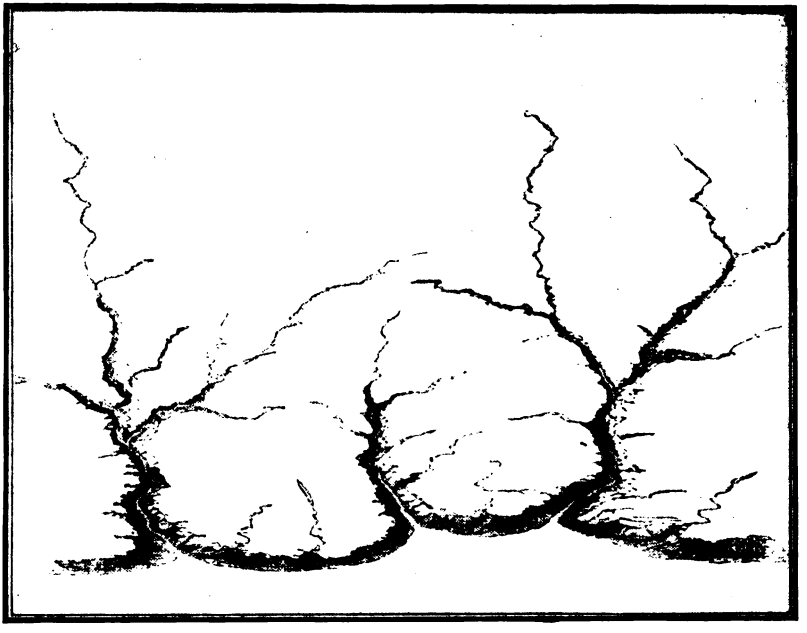

Fig. 1. YOUNG VALLEYS.

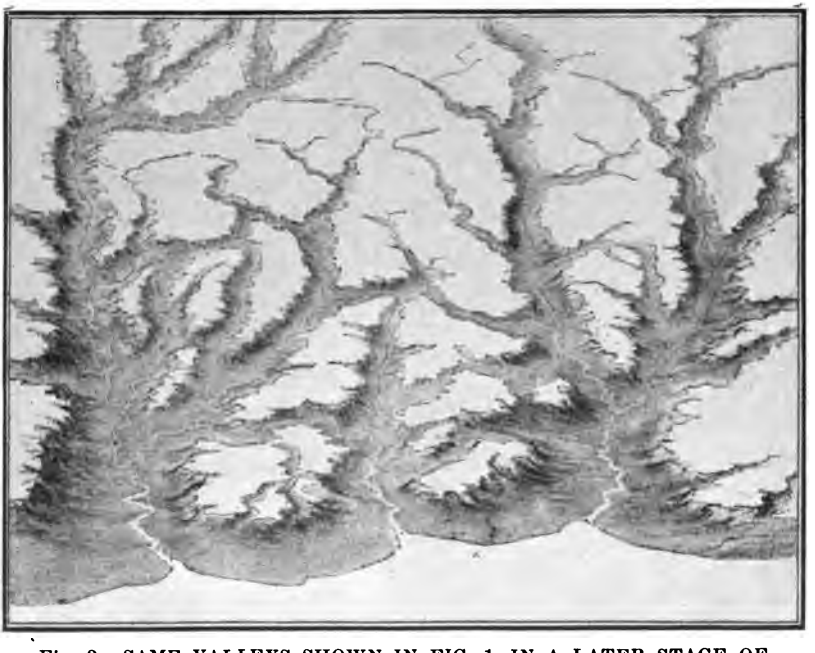

Fig. 2. SAME VALLEYS SHOWN IN FIG. 1, IN A LATER STAGE OF DEVELOPMENT.

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undulating hills generally reach a height of 50 to 100 feet above the surrounding lower land.

The terminal moraine of the Chippewa valley ice lobe extends from the vicinity five or six miles north of Stanley westward to Jim Falls on the Chippewa river, then turns to the north and passes through the west central part of Chippewa county and along the border of Rusk and Barron counties, crossing the northeast part of Barron county in the region of Red Cedar lake. From the vicinity of Haugen there is another belt of moraine, formed by the St. Croix valley ice lobe, lying across the northwestern part of the area and extending through the vicinity of Cumberland, Turtle Lake, Clear Lake, New Richmond, Chapmans and Glover. The topography of terminal moraine is illustrated in Plate VIII.

Origin of the Terminal Moraines.—The terminal moraines are the thickened belts of drift accumulated at the margin of the ice sheets, where the ice margins remained essentially constant for a considerable time. A large amount of drift material gathered by the ice in the advance is dropped at the edge of the ice on account of the wastage of the ice by melting.

Rivers and Valleys.—The Chippewa river is the largest river, and, with its tributaries, drains about two-thirds of the area. Its principal tributaries flowing from the east are the Eau Claire, Yellow, Jump, Flambeau and Thornapple. On the west side of the Chippewa the main tributaries are the Eau Galle and Red Cedar. North of Chippewa Falls the Chippewa river has a broad shallow valley, but to the south the river has a deep valley bottom bounded on both sides by abrupt uplands rising from 100 to 200 feet or more above the sandy river bottoms. A series of terraces occur along the valley bottom from the vicinity of Chippewa Falls down to the Mississippi.

The Eau Claire river has a sandy valley bottom relatively narrow near its junction with the Chippewa but very wide in the eastern part of Eau Claire county. The Yellow river has a broad sandy plain below Cadott, but farther up stream the river winds among drift hills with no marked valley depression. The Jump and Flambeau rivers are not intrenched in prominent valleys but have their courses in broad drift-covered, slightly undulating plains.

The Red Cedar river drains about one-fourth of the area.

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In its lower course from Cedar Falls to its mouth, the river flows in a narrow rocky gorge. The upper part of the valley is quite broad and in striking contrast with the lower narrow portion. It is very probable that the broad valley east of the river about Rusk prairie, was originally the main valley of the Red Cedar, and that the river below Cedar Falls is at present in a relatively new channel. The valley about Chetek, Cameron and Rice Lake is a broad plain from two to six miles wide.

The Eau Galle river in the vicinity of Woodville and further north has a broad valley, but south of this it has a relatively deep valley from 100 to 200 feet deep with precipitous banks on either side. At Spring Valley the valley bottom is narrow, generally less than one-half mile wide, but farther south it gradually widens, being about a mile wide below Eau Galle where it opens out into the valley of the Chippewa.

The Mississippi and the St. Croix rivers form the western boundary of the area. The Mississippi river has a prominent valley bounded by steep escarpments rising abruptly from 200 to 500 feet above the river. The principal tributaries flowing into the Mississippi are the Rush river, Isabel creek, Trimbelle river, and Big river. All these tributaries have deep prominent gorges in their lower courses. The valley of the Rush is prominent as far north as Martell.

The St. Croix river lies in a relatively deep valley throughout its course in this area. The valley is especially prominent and picturesque at St. Croix Falls and south as far as Stillwater. South of St. Croix Falls at the Delles of the St. Croix, the banks of the river rise abruptly to heights of 150 to 200 feet. From Stillwater to Prescott the river broadens out into Lake St. Croix.

The principal tributaries of the St. Croix in this area are the Kinnikinnic, Willow, and Apple rivers. The Kinnickinnic below River Falls has a deep and narrow valley with precipitous banks. The Willow below Burkhardt is prominent. The valley of the Apple is fairly prominent below Somerset, and especially prominent below Big Falls only a short distance from the St. Croix.

Origin of the Rivers and Valleys.—The valleys were carved out of the surface of the land by the erosion of the rivers and streams that flow through them. Rivers and valleys therefore

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Fig. 1. DEVELOPED WATER POWER ON THE CHIPPEWA RIVER AT EAU CLAIRE.

Fig. 2. UNDEVELOPED WATER POWER ON THE CHIPPEWA RIVER AT BRUNETTE FALLS.

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are so closely connected in life history that they can best be described together.

The rains that fall upon the land surface flows off the slope and tends to gather into rills and to wash out gullies as illustrated upon every hillside after any considerable shower. The gullies grow into ravines, and the ravines grow into valleys by the simple work of running water. By constant erosion the valleys lengthen and broaden out and the inter-valley areas become narrower and narrower, as illustrated in the figures of Plate IV.

Rivers and streams work untiring throughout their courses. The more rivers are studied the more wonderful their place in nature is found to be. They wash along in every part of their course the waste of the land on the way to the sea.

Falls and Rapids.—Falls and rapids are common features of the rivers of this area. These are usually developed in the valleys where the streams cross from a more resistant rock to a less resistant one. In the course of time, however, the streams will succeed in cutting down these harder rocks of the rapids to grade with the stream above and below. Rapids and falls, therefore, belong to the youthful stage of a valley history rather than to that of old age. Waterfalls and rapids are an important natural resource of the area and many of them have already become sites for the development of valuable water power. The location of nearly all the large cities and villages of the area has been determined by the presence of rapids. The cities of Eau Claire, Chippewa Falls, Menomonie, Rice Lake, River Falls, New Richmond, Ladysmith, Barron, Cumberland, St. Croix Falls and many small villages are located on river rapids. Examples of river rapids and developed power on the Chippewa river are illustrated in Plate V.

Lakes.—The districts containing lakes and swamps lie in the northeastern and in the northwestern parts of the area, as may be seen on the map, Plate I. In the northwestern part of Chippewa and southwestern Rusk counties, the most prominent lakes are Long lake, Island lake, and Potatoe lake. In Barron county are Chetek, Prairie, Pokegema, Rice, Red Cedar, Bear, Beaver Dam, and Big Horse Shoe lakes. The most prominent lake in St. Croix county is Bass lake. In Polk county there

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are many lakes, the largest being Cedar lake, Sucker lake, Round lake, Balsam lake, and Bone lake.

Lake Pepin, an enlargement of the Mississippi river and Lake St. Croix, a similar enlargement of the St. Croix river are prominent lakes on the western border of the area.

Origin of the Lakes.—The existence of any hollow which is capable of holding water may give rise to a lake and hence many of the sags and depressions in the terminal moraines are occupied by lakes and ponds. Many lakes in this area also are due to the depressions of drift in pre-existing valleys. Such elongated lakes as Red Cedar, Bear, Beaver Dam, Bone lake and Sucker lake were formed by the blocking of valleys by the drift.

Another type of lake is formed in the abandoned meanders of the large rivers, such as the Chippewa and St. Croix. Lake Hallie, north of Eau Claire, is an example of this type.

The life history of lakes is transitory as compared with that of rivers. The lakes of the area are comparatively recent in origin and do not date back beyond the formation of the last two drift sheets. The usually recognized processes operating to destroy lakes are three: the down-cutting of the outlet, thereby draining the lake; the filling of the lake by detritus eroded from the lake shore or brought in by streams; and the accumulation of organic matter, both vegetable and animal, such as peat and marl, formed in the lake itself.

Rock and Mineral Supplies.

The rock formations of the area furnish material for various useful purposes. The crystalline rocks, occurring as boulders in the glacial drift, or in the solid rock ledges are used to a variable extent as crushed stone for road material. The Potsdam sandstone furnishes good building stone in many localities. The important sandstone quarries at Colfax and Dunnville supply large quantities of good building stone. The limestone is quarried for building stone for local uses in Pierce, Pepin and St. Croix counties. The limestone in the vicinity of Spring Valley is used as a flux in the Spring Valley Iron Furnace. It was also formerly burned for lime at various lime kilns in one area but this industry has been largely discontinued.

Common brick clays occur abundantly throughout the area.

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An important brick industry is carried on in Menomonie and Tramway in Dunn county. The manufacture of brick is carried on also at Chippewa Falls, Stanley, Ladysmith, Barron, St. Croix Falls, Amery, Barronett, Spring Valley, River Falls, Durand and Ellsworth. At present drain tile is not manufactured at any of these yards. Drain tile is made from the more plastic and finer-grained brick clays. Good drain tile could probably be made at several of the brick yards mentioned.

Good road material is abundantly supplied in the drift covered areas by the boulders and gravel in the drift. The trap rock ridges of Polk county, the granite ledges along the Chippewa river and tributaries in Eau Claire, Chippewa and Rusk counties are available sources for crushed rock for the construction of macadamized roads and streets. In the vicinity of Eau Claire the Potsdam shale is used quite extensively to improve the sandy roads.

Water Supplies.

The many streams and lakes of the area furnish an abundant supply of good water for stock. At most of the farm houses, however, wells are mainly relied upon to furnish water for domestic purposes.

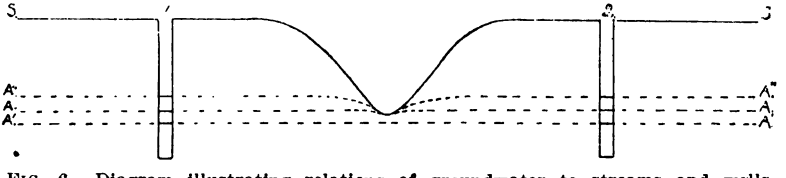

FIG. 6.—Diagram illustrating relations of groundwater to streams and wells. The dotted line AA represents the usual groundwater level which rises to A" A" in wet seasons and sinks to A' A' in dry seasons.

Well water is found at various depths below the surface, depending mainly upon the general topography, the distance above the permanent stream levels, and the character of the underlying rock formations. At certain depths below the surface all the pores and fissures in the rock are filled with ground water and it is into this water-filled portion of the ground that wells must be sunk in order to obtain an abundant and constant supply. The upper surface of the ground water, the ground water level, is usually very near the level of the permanently flowing streams and rivers of the area. The level of ground-

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water is not exactly horizontal but is slightly undulating in general conformity with the topography of the land surface. The relation of the ground water level to streams and wells is shown in the diagram, fig. 5.

Some of the lake levels of the small lakes in northeastern St. Croix county, are somewhat unusual in being far above the general level of the groundwater. Wells in the immediate vicinity of these lakes go down 50 to 100 feet below the lakes to reach the ground water level and obtain a permanent water supply.

Changes in Groundwater Level. The level of groundwater rises and falls from season to season depending upon the seasonal rainfall. It also changes locally from year to year, due to amount of annual rainfall. The ground water level is also appreciably lowered where considerable pumpage or flowage from wells takes place.

Character of the Well Water. The well water within the area, is known in domestic economy as "soft water" and "hard water." The soft waters are located within the general area of the sandstone and crystalline rocks in the northeastern and eastern parts of the area and the hard waters are mainly confined to the area of the limestone in the western part. One of the softest waters in the United States is the famous Chippewa Spring water of Chippewa Falls. A well known mineral water, is used extensively for bottling purposes, at the Bethania Mineral Springs at Oceola. North of Osceola a few miles, is a flowing well, made in exploring for copper, which is unusually strongly mineralized.

It is possible therefore, to find waters within the area, containing but slight traces up to large amounts of mineral matter, though in general the well waters usually used for domestic purposes are only the ordinary phases of hard and soft waters. Much of the glacial drift of the northwestern part of the area in Polk and Barron counties contains much limestone material and hence the waters from these localities are also generally hard waters.

Wells in the Alluvial Sands and Gravels. Abundant well water is readily obtained in the sandy and gravelly stretches along the rivers and main streams of the area. Very generally the wells are sunk to the approximate level of the adjacent

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rivers. Along the Chippewa river south of Chippewa Falls, the wells on the highest benches of the alluvial plains are from 50 to 100 feet deep. In the broad sandy plains of eastern Eau Claire county and in northern Chippewa, in Rusk, Barron, and Polk counties, wells are usually shallow, only from 10 to 30 feet deep. As a rule in order to secure good pure water the wells should obtain their supply more than 20 feet below the surface and where the groundwater stands less than 20 feet from the surface, drive wells or drilled wells should be made.

Wells in the Glacial Drift. Water is found at various depths in the sand and gravel of the glacial drift. The deepest wells in the drift, usually from 50 to 100 feet deep, are those in the hilly portions of the terminal moraines. On the more level areas of the drift the wells usually vary from 20 to 40 feet in depth. Where the drift overlies the crystalline rock, as in the northeast part of the area, abundant water is usually found within the drift, or at the contact with the underlying crystalline formations. Where the drift overlies limestone and sandstone however, the wells usually have to penetrate the latter to a variable depth to the general level of the underground water.

Wells in the Potsdam Sandstone. Wherever the sandstone has a thickness of 10 to 20 feet or more and the land is gently sloping, it usually furnishes an ample supply of water. The wells in the sandstone ridges and uplands usually have to reach down to the level of the surrounding low lands along the running streams to obtain a water supply.

Wells in the Limestone. The wells in the limestone rock are mainly confined to Pepin, Pierce and St. Croix counties. In Pepin and Pierce, while the wells penetrate limestone, the water supply is generally obtained from the underlying formation of Potsdam sandstone. In St. Croix, however, many wells obtain water from the Lower Magnesian limestone at depths of 50 to 150 feet below the surface. Many wells in Pierce county on the limestone uplands are from 150 to 300 feet deep and obtain water from the underlying Potsdam sandstone. In some places in St. Croix county where the St. Peter sandstone contains a thin bed of shale at its base, a water supply is obtained where the wells reach these shale beds but do not penetrate through.

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Wells in The Crystalline Rocks. Wells that obtain their water supply from the crystalline rocks are mainly confined to northeastern Chippewa and Rusk counties and along the belt of trap rock in central Polk county. The wells in the trap rock in Polk are of varying degree of efficiency, and occasionally it is impossible to get a satisfactory supply from this formation. Where there is an overlying formation of drift or sandstone having a thickness of 10 to 20 feet which may serve as a catchment basin for water, a supply can be obtained by going down to the trap rock or a short distance into it.

The crystalline rocks in northern Chippewa and Rusk counties quite generally furnish a sufficient supply of water for domestic purposes. Where the overlying drift and sand is more than 15 or 20 feet thick, a supply can generally be obtained at the contact with the crystallines or within a few feet into the latter formation. Where the crystalline rock is massive and in solid formation, it is more difficult to obtain water than in the much fractured and fissured rock, for it is from the openings in the rocks that the water is obtained.

In drilling wells in the crystalline rocks, the heavier drills should be used, those having a combined weight of bit and stem of 1200 to 1400 pounds. The light weight drills usually make too slow progress. The possible clogging of water passages in drilling crystalline rock should be taken into account.

In the crystalline rocks most of the water is near the surface because of the larger proportion of rock opening near the surface, and hence, dug wells are often much more satisfactory than drilled wells. The dug wells being of larger diameter open up a larger number of veins and fissures and also have a larger storage capacity and on this account need not be so deep as the drilled wells.

Artesian Wells. Artesian flowing wells are obtained in the southwestern part of the area, on low ground along some of the rivers and streams. The sources of the flows are in the Potsdam sandstone and also in the alluvial formations in the valleys. The Artesian wells in Durand obtain their flows from depths of 200 to 500 feet, the water rising 25 to 35 feet above the level of the Chippewa river at Durand. The flowing wells that furnish running water for the Fish Hatchery at Hudson have their

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source in the alluvial sand and gravel of the Willow river and are only from 10 to 15 feet deep and rise only a foot or so above the general level of standing water. There are some flowing wells also near Arkansaw and in the vicinity of Osceola.

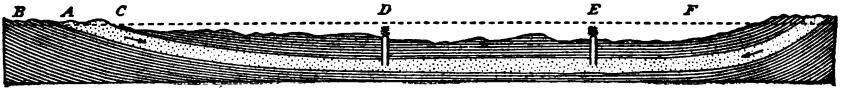

FIG. 7.—Section of an artesian basin. *A*, Porous stratum; *B*, *C*, impervious beds below and above *A*, acting as confining strata; *F*, height of water level in porous beds *A*, or, in other words, height in reservoir or fountain head; *D*, *E*, flowing wells springing from the porous water-filled bed *A*.

It is only on very low ground in Pepin, Pierce, St. Croix, and Polk counties that artesian flows are likely to be obtained. In the southeastern part of the area, artesian flows are not known at present, though they might be developed occassionally in small restricted areas in the glacial drift or in the alluvial deposits.

Origin of Flowing Wells. The water in wells that flow at the surface is under pressure. The essential condition for the existence of a flowing well is a relatively porous stratum lying between impervious strata, or below one; the porous stratum which transmits the water having an outcrop or catchment area at a higher elevation than the water bearing stratum at the well. In this manner the water in the porous stratum is held under pressure and when penetrated by a well the water tends to rise up to the level of the intake. There are many qualifying conditions that effect the quantity of the flow or the pressure. Artesian systems of flowing wells are lllustrated in figures 7 and 8.

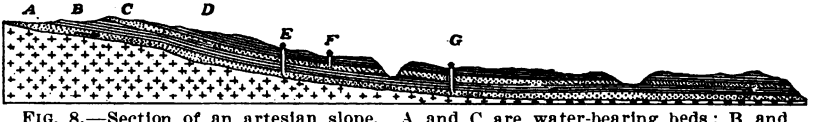

FIG. 8.—Section of an artesian slope. A and C are water-bearing beds; B and D are relatively impervious beds acting as confining strata; E, F and G are flowing wells springing from the water-bearing beds.

Springs. There are many large springs in the southwestern part of the area, along the lower Chippewa river, the St. Croix, and Mississippi, and the tributaries in Pierce county. The copious springs at St. Croix Falls along the St. Croix are a well known feature of that locality.

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Origin of Springs. A "spring" is properly applied to the water emerging from the ground at a single point or within a small restricted area. Seepage springs are springs in which the water seeps out of sand or gravel. Such springs are usually marked by abundant vegetation, and their waters often carry a scum due to the decomposition of vegetable matter or the presence of iron. The scum is frequently mistaken for petroleum. Springs of this kind commonly occur along the sides or bottoms of valleys, as illustrated in figure 9.

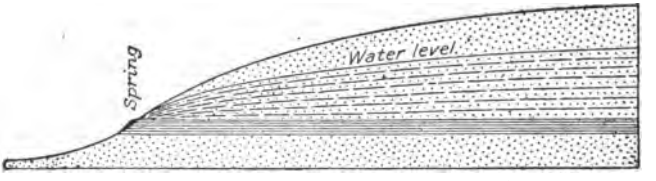

FIG. 9.—Spring fed from unconfined waters in porous sand.

Fissure springs are those that issue along bedding, cleavage, or fault planes. The waters are deeper seated and are almost never subjected to contamination. The accompanying diagram, fig. 10 illustrates a typical fissure spring. The springs at Ilwaco on the St. Croix river are of this type.

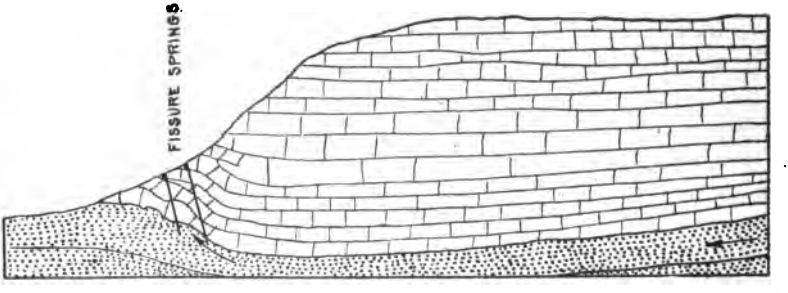

FIG. 10.—Fissure spring. Waters spring from the underlying porous sandstone up through fissures in the limestone.

The Pollution of Well and Spring Water. Farms, which are generally remote from towns and cities or other areas of congested population are especially favorably situated for obtaining pure and wholesome water. As a matter of fact, however, polluted water is exceedingly common on the farms, and typhoid fever, generally contracted from drinking water, is usually more prevalent in country districts than in cities.

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Many of the failures to protect water supplies used for drinking are due to a lack of knowledge of the manner in which waters circulate through the ground and of the ways in which the ground water may become polluted. The diagram, fig. 11 illustrates the location of safe and unsafe wells, and the general relation of these to the location of farm buildings and to the ground water level.

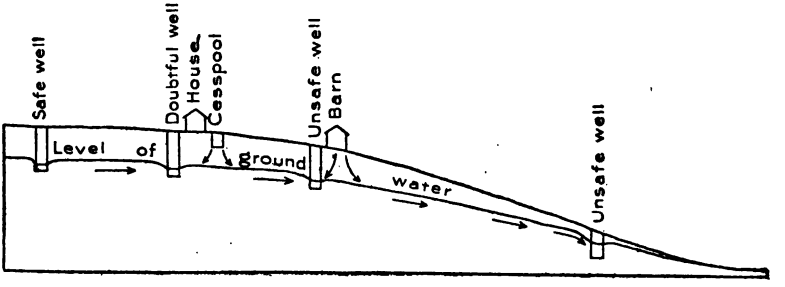

FIG. 11.—Diagram showing location of safe and unsafe wells and their relation to farm buildings.

Springs may also be contaminated, especially the seepage springs, if proper care is not taken in the location of buildings near the spring. Open or dug wells may be polluted by material seeping through the ground and curbing or entering from the top of the well.

The distance from a source of pollution, such as cesspools and barnyards, at which a surface or open well may be sunk with a fair degree of safety varies with the formation but generally should never be less than 100 feet and often should be at least 200 feet. The more open and porous the soil and the more rapid the movement of the ground water, the greater is the safety distance required. Well waters that become muddy after rain storms indicate surface contamination and should be avoided

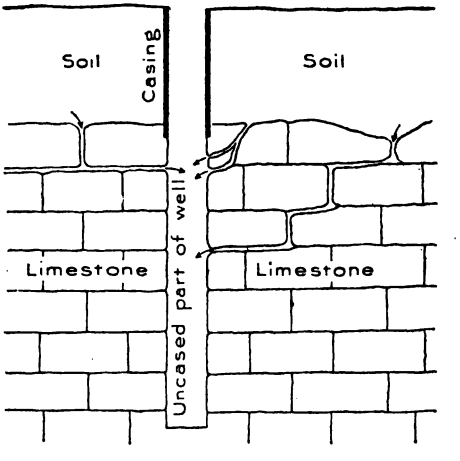

FIG. 12. Diagram showing danger of pollution where casing is carried only to rock.

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if possible. Wells should be protected from surface water by properly constructed curbing, stock should be kept away from the well, and protection from pump drippings, from small animals, and dust should be ensured, as they are all possible sources of pollution.

The water of deep wells are usually safe and hence many people go to the expense of drilling for deep well water. Deep wells, may however become polluted by the entrance of surface waters (See fig. 12) unless the casing is carried into the well a sufficient depth to shut off all surface water entering through fissures.

Cisterns, which are especially valuable in supplying soft rain water or in furnishing supplementary supplies from wells, if properly constructed are safe sources of water supply. The disadvantage of cisterns is the liability of contamination by dust from the roof, and the liability to crack and admit shallow and possibly polluted waters.

WATER POWERS.

The water powers are a valuable natural resource of the area. A general survey of the water powers of the state has been made by L. S. Smith.* Much less than one-half of the available water power in the area is now developed. On the Chippewa river extensive power is developed at Eau Claire and Chippewa Falls, and on the Flambeau at Ladysmith. There are very many power sites still undeveloped on the Chippewa and Flambeau, among which may be mentioned the important sites at Jim Falls, Brunett Falls, and Holcombe on the Chippewa, and Burnt Island, Big Falls, and Cedar Rapids, on the Flambeau.

Water powers have been developed on the Red Cedar at Menomonie and Chetek, and on the tributaries of the Red Cedar at Rice Lake and Barron. The St. Croix river has many power sites in its upper course. At St. Croix Falls, is a 50 foot dam, having an estimated development of 27,000 H. P. at present only partially equipped, the power being conducted electrically to Minneapolis and St. Paul. There are no powers developed above St. Croix Falls but important sites are located at Nevers

* Bulletin No. 20, Wis. Geol. & Nat. Hist. Survey, Madison, Wis.

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dam, at Kettle River rapids and farther north. Powers are developed on the Kinnickinnic river at River Falls, on the Willow at Burkhardt and New Richmond, and on the Apple at Apple River Falls, Somerset, and Huntington, the power developed on the Apple river, being conducted to Stillwater and Minneapolis.

ALTITUDES OF NORTHWESTERN WISCONSIN.

Elevations above sea level, of many of the railroad stations within the area, some of which are also indicated on the soil map, are shown in the following table:

TABLE I.—*Altitudes of railroad stations.*

Station.	Altitude.	Station.	Altitude.
Amery	1,070	Hammond	1,104
Augusta	972	Hersey	1,201
Baldwin	1,136	Holcombe	1,045
Barron	1,111	Hudson	699
Bloomer	1,012	Knapp	928
Boyd	1,105	Ladysmith (on river above dam)	1,110
Bruce	1,098	Luck	1,207
Burkhardt	927	Maiden Rock	696
Cadott	977	Menomonie, C. St. P. M. & O.	788
Cameron	1,098	Menomonie Junction	884
Chetek	1,053	New Auburn	1,109
Chippewa Falls, C. St. P. M. & O.	866	New Richmond, W. C. R. R.	986
Chippewa Falls, W. C. R. R.	831	Osceola	809
Clear Lake	1,198	Pepin	688
Colfax	947	Prairie Farm	
Cumberland	1,241	Prescott	706
Dallas	1,052	Rice Lake	1,148
Durand	725	Ridgeland	1,083
Eau Claire, C. M. & St. P.	788	River Falls	886
Eau Claire, C. St. P. M. & O.	841	Roberts	1,039
Elk Mound	931	St. Croix Falls	920
Ellsworth	1,068	Spring Valley	922
Fairchild	1,018	Stanley	1,077
Fall Creek	939	Stockholm	692
Frederick	1,204	Turtle Lake	1,258
Glenwood	1,026	Woodville	1,152

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TABLE II—*Altitudes of points on the important rivers.*

Station.	Altitude.	Station.	Altitude.
Chippewa River.		*Red Cedar.*	
Reeds Landing—High water.	680	Mouth of River....	705
Reeds Landing—Low water..	664	Dunnville.....	723
Eau Claire River, mouth.....	770	Irving.....	766
Chippewa Falls, foot of dam.	806	Menomonie, foot of dam.....	788
Yellow River, mouth.....	852	Cedar Rapids, foot.....	823
Jim Falls, foot.....	901	Hay River, mouth.....	859
Brunett Falls, foot.....	967	Colfax.....	895
Holcomb Rapids, foot.....	1,004	Cameron, (2 miles west).....	1,068
Flambeau River, mouth.....	1,050	Rice Lake (R. R. crossing)....	1,116
Bruce, Sec. 28.....	1,064	Cedar Lake, dam.....	1,191
Murray, N. E. Sec. 23.....	1,112		
Flambeau River.		*St. Croix River.*	
Ducommon Rapids.....	1,070	Prescott, mouth of river..... Low water	667
Ladysmith, below dam.....	1,099	Kinnikinnic River, mouth....	668
Little Falls Rapids.....	1,137	Apple River, mouth.....	672
Big Falls, foot.....	1,177	Osceola.....	683
Big Falls, head....	1,209	St. Croix Falls (head of navigation.....	687
Rock Island rapids.....	1,233	St. Croix Falls (crest of dam)	750

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CHAPTER II.

CLIMATE.

The climate of the area is not influenced by the Great Lakes but is influenced in a general way by its location with respect to the average track of the storms that move eastward, along the Canadian border, and those that move up the Mississippi valley from the southwest. As in other parts of the northern Mississippi Valley, extremes of temperature prevail, the summers being warm with abundant precipitation, and the winters cold and relatively dry.

Temperature. The climatic elements of greatest importance to agriculture are temperature and precipitation. The temperature conditions of the area, are shown in the two tables, Table III and IV. The period covered is from 15 to 21 years, the period ranging from 1890 to 1909, the data being compiled from a recent sectional report of the U. S. Weather Bureau of northwestern Wisconsin. There are at present nine Weather Bureau stations within and near the area, but of these five have records of observations for only a relatively short period, of three to five years. The stations at present in the area or near the area, are located at Barron, Downing, Grantsburg, New Richmond, Osceola, Stanley, Weyerhauser, Eau Claire, Ellsworth and Red Wing, Minn. In compiling the temperature data, only the stations at Barron, Osceola, Downing, Eau Claire and Grantsburg and Red Wing, Minn. are considered. Grantsburg, located in Burnett county, is but a short distance north of Polk county.

Table III shows the mean temperature conditions for the growing season of the year, from April to September. The mean or average temperature for each of the six stations for each month is given, and also the highest, and the lowest temperatures for each month. The mean temperature is the most important

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datum to consider in agriculture, as the highest and lowest temperatures represent only the rare and extreme conditions.

By comparing the data for the several stations, it will be observed that the mean temperatures are almost identical at all the stations for the summer months, and yet there is a slight and persistent difference between them which is worthy of note. The temperature of Barron is about one to two degrees colder than that of Osceola and Grantsburg, and about two to four degrees colder than that of Eau Claire.

The table indicates that the summer isothermal lines or lines of equal temperature do not run east and west across the area, but run northwest and southeast. The summer temperatures of Eau Claire Dunn, and St. Croix counties are about the same. In the same way the summer temperatures of Chippewa and Polk would be the same. Rusk county is the coldest in the summer, and Pierce and Pepin counties the warmest as indicated by the records at Red Wing.

The Table IV showing the temperature for the non-growing season indicates that the temperature of Barron and the northeastern part of the area is slightly colder in winter than the western part of the area at Grantsburg and Osceola, as well as colder than the southern part of the area at Eau Claire. At all the stations there are much greater extremes in temperature in winter than in summer.

While the mean temperatures are the most important data in the tables, extremes of temperature are also of interest. The unusually low temperatures recorded in the area have reached 40° to 48° below zero, and unusually high temperatures have reached 100° to 105° above zero. There are generally from 5 to 10 days in winter when temperatures below 20° below zero may be expected, and from 5 to 10 days in summer when temperatures above 90° may occur.

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TABLE III.—*Temperature of the growing season* (Fahrenheit).

STATION.	Elevation.	Length of record, years.	APRIL.			MAY.			JUNE.			JULY.			AUGUST.			SEPTEMBER.		
			Mean.	Highest.	Lowest.	Mean.	Highest.	Lowest.	Mean.	Highest.	Lowest.	Mean.	Highest.	Lowest.	Mean.	Highest.	Lowest.	Mean.	Highest.	Lowest.
Barron	1,115	18	42.2	88	10	52.9	94	18	63.4	97	25	68.2	103	40	64.9	98	34	58.5	90	22
Grantsburg	1,095	18	43.1	83	—7	54.6	93	15	64.8	98	23	69.1	105	39	66.4	98	33	58.6	93	16
Osceola	806	19	43.4	87	—4	54.6	93	16	64.7	99	25	69.1	105	34	67.0	104	30	59.9	99	20
Downing	983	15	43.2	84	4	54.7	98	17	64.4	100	28	67.9	103	35	66.7	100	32	58.6	97	12
Eau Claire	800	19	45.6	88	11	57.0	94	20	66 8	97	25	70.7	103	41	69.2	98	36	61.1	99	20
Red Wing, Minn	708	21	45.7	89	16	56.0	92	25	67.9	99	38	72.0	106	46	68.6	95	45	61.1	95	33

TABLE IV.—*Temperature of the non-growing season* (Fahrenheit).

STATION.	Elevation.	Length of record, years.	OCTOBER.			NOVEMBER.			DECEMBER.			JANUARY.			FEBRUARY.			MARCH.		
			Mean.	Highest.	Lowest.	Mean.	Highest.	Lowest.	Mean.	Highest.	Lowest.	Mean.	Highest.	Lowest.	Mean.	Highest.	Lowest.	Mean.	Highest.	Lowest.
Barron	1,115	18	45.7	86	10	29.5	72	—15	16 3	54	—28	10.3	54	—40	11.4	59	—40	25.5	75	—18
Grantsburg	1,095	18	46.8	84	7	30.8	75	—32	16.7	58	—39	10.9	52	—43	11.8	52	—45	26.2	73	—27
Osceola	806	19	46.8	86	3	29.7	70	—34	16.3	52	—40	10.0	67	—46	11.6	59	—47	26.6	73	—27
Downing	985	15	46.7	85	9	30.3	75	—24	16.7	53	—33	11.1	50	—44	12.3	62	—48	27.4	77	—20
Eau Claire	800	19	48.6	86	10	32.1	72	—15	18.7	54	—28	13.1	54	—34	14.3	59	—40	28.7	75	—18
Red Wing, Minn	708	21	48.7	80	18	33.3	78	— 9	20.1	50	—25	11.2	45	—31	15.1	50	—30	27.4	64	— 7

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Precipitation. The precipitation,* which includes the snowfall as well as the rainfall, at the stations, Grantsburg, Osceola, Downing, Barron, Red Wing, and Eau Claire, is shown in the following tables:

TABLE V.—*Grantsburg, Burnett County, Wis.*

(Elevation, 1,095 feet.)

Year	January	February	March	April	May	June	July	August	September	October	November	December	Annual
1889.....	....	....	....	2.55	3.4	1.96	4.00	....	4.01	T.	0.55	1.95	....
1890.....	1.20	....	2.25	....	[illegible]	10.76	6.17	7.51	2.50	1.55	0.71	....	....
1891.....	....	...	....	....	....	....	....	....	....	....	....	....	....
1892.....	....	....	....	....	....	....	....	....	....	....	1.10	0.80	....
1893.....	1.40	2.35	0.90	3.35	2.45	2.20	1.21	2.03	1.40	2.60	0.90	2.20	22.99
1894.....	1.40	0.20	2.40	5.15	7.41	1.41	0.55	0.72	1.80	3.72	1.80	1.37	27.93
1895.....	0.99	0.40	0.40	1.76	4.61	5.09	4.36	2.50	4.70	0.04	0.65	0.50	26.00
1896.....	1.15	0.50	2.57	7.10	5.91	3.47	1.30	1.53	2.63	4.22	4.75	1.35	36.48
1897.....	1.35	1.28	2.70	0.75	2.00	7.93	9.67	2.00	3.65	1.70	1.04	0.35	34.42
1898.....	0.39	0.88	2.12	1.64	4.85	6.00	1.59	2.67	1.90	5.30	1.80	T.	29.14
1899.....	0.77	1.57	2.56	2.50	5.97	2.30	2.08	4.89	1.63	4.63	0.67	1.93	31.50
1900.....	0.77	1.42	0.67	1.19	1.31	1.35	8.77	9.43	4.60	4.43	1.05	0.75	35.74
1901.....	0.50	0.65	3.98	1.65	1.13	5.26	3.49	2.13	4.25	1.68	0.88	1.02	26.62
1902.....	0.85	0.05	0.75	1.99	2.85	2.98	5.31	1.36	3.55	1.82	3.05	2.68	27.24
1903.....	0.82	1.90	2.17	4.25	6.55	1.12	9.37	5.70	10.02	3.14	0.60	1.50	47.23
1904.....	0.70	1.55	0.65	1.25	3.08	5.33	4.76	3.68	7.23	5.04	T.	1.50	34.77
1905.....	1.45	0.55	1.20	1.40	3.19	9.81	5.53	5.18	7.73	3.20	2.48	T.	41.72
1906.....	3.05	0.80	1.10	3.56	4.95	7.08	2.38	4.08	2.61	2.41	1.93	1.60	35.55
1907.....	1.80	0.90	2.30	0.85	2.15	7.11	4.35	2.44	9.38	0.40	1.00	0.50	33.18
1908.....	0.55	1.66	2.35	5.13	8.22	8.38	3.05	0.94	1.90	2.38	0.42	0.90	35.88
1909.....	0.90	2.15	0.45	4.02	3.50	1.57	5.75	3.28	3.93	3.03	3.50	2.50	34.58
Means..	1.11	1.11	1.75	2.78	4.11	4.80	4.40	3.45	4.18	2.70	1.44	1.23	33.06

Osceola, Polk County, Wis.

(Elevation 806 feet.)

1891.....	0.90	1.80	2.30	2.05	1.95	4.52	2.38	1.02	1.52	1.66	1.22	3.93	25.25
1892.....	0.03	1.47	1.13	1.32	8.10	8.14	6.22	4.64	1.34	0.62	0.49	0.63	34.13
1893.....	1.48	2.45	2.91	3.62	2.58	2.08	3.17	2.18	2.04	3.42	0.79	1.97	28.67
1894.....	1.07	0.15	2.80	4.74	9.95	2.40	0.44	0.65	1.85	4.69	0.13	1.60	30.47
1895.....	0.86	0.24	0.55	1.95	4.67	4.31	5.35	1.83	5.72	0.22	1.14	0.16	27.00
1896.....	0.71	0.10	2.34	5.67	4.86	6.63	1.83	4.38	2.77	3.54	3.20	0.79	36.82
1897.....	2.50	0.73	2.09	1.34	1.60	7.30	4.94	1.35	3.76	2.11	1.32	0.11	29.15
1898.....	0.03	1.13	4.43	1.83	6.60	4.92	1.32	4.24	0.87	5.67	1.69	0.07	32.60
1899.....	0.90	1.30	2.19	2.86	3.41	6.85	1.66	4.87	1.06	3.72	1.02	1.54	31.38
1900.....	0.35	0.92	0.70	1.95	0.36	0.90	9.76	7.96	8.14	6.08	0.71	0.67	38.50
1901.....	0.38	0.68	3.24	1.51	1.74	6.40	3.79	2.35	5.20	1.71	1.87	2.28	31.15
1902.....	0.76	1.42	0.80	1.95	2.54	3.02	3.98	3.60	3.99	1.23	2.55	2.11	27.95
1903.....	0.67	0.44	2.09	2.92	7.31	2.26	9.58	4.42	8.76	4.14	0.20	0.83	43.62
1904.....	0.70	0.88	1.37	1.52	5.21	5.84	5.05	3.54	5.66	5.32	T.	0.50	35.39
1905.....	0.35	0.78	0.73	0.62	2.77	6.27	2.65	5.35	6.01	2.62	1.80	0.20	30.15
1906.....	4.50	0.18	3.50	1.55	6.61	4.07	5.02	2.56	3.75	3.20	1.77	1.97	38.69
1907.....	1.39	0.53	0.70	1.05	0.66	3.35	4.51	2.98	7.33	1.45	1.12	0.20	25.27
1908.....	0.55	0.85	1.45	3.61	8.23	5.50	3.05	0.79	3.32	2.43	0.98	0.70	31.46
1909.....	0.86	1.41	0.85	2.50	2.05	5.68	3.53	3.66	3.80	2.20	4.45	1.92	32.91
Means..	1.00	0.92	1.90	2.33	4.27	4.75	4.12	3.28	4.05	2.95	1.39	1.17	32.13

* From Weather Bureau Report, Section 58, Northwestern Wisconsin.

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Downing, Dunn County, Wis.

(Elevation, 983 feet.)

Year	January	February	March	April	May	June	July	August	September	October	November	December	Annual
1891.....	2.05	2.63	3.12	3.37	2.14	4.30	2.44	3.85	1.41	4.16	0.52	5.33	35.32
1892.....	0.47	1.90	2.09	2.13	7.46	5.83	8.31	2.91	2.90	2.60	0.76	1.09	38.35
1893.....	1.43	3.53	2.81	6.17	2.55	1.54	2.81	2.33	2.59	2.93	0.77	4.01	33.47
1894.....	1.25	0.32	3.02	5.65	10.56	1.90	0.42	0.50	2.93	4.33	1.93	1.68	34.49
1895.....	1.23	0.55	....	....	....	....	....	....	....	....	....	....	.....
1896.....	....	....	....	....	....	....	....	....	....	....	....	....	.....
1897.....	....	....	....	....	....	....	....	....	....	....	....	....	.....
1898.....	0.25	1.04	0.87	1.23	2.67	4.86	2.11	3.55	0.89	4.45	1.04	T.	22.76
1899.....	0.65	0.60	1.10	1.60	5.87	8.37	1.64	4.91	3.42	4.45	0.80	1.90	35.31
1900.....	0.31	0.51	1.10	2.00	0.04	2.46	10.55	4.34	9.46	7.48	0.37	0.95	39.55
1901.....	....	....	....	2.15	....	....	....	1.31	5.20	1.39	....	....	.....
1902.....	0.60	0.90	0.30	2.15	3 80	3.00	3.73	2.00	2.45	1.65	3.80	3.81	27.99
1903.....	0.30	0.05	2.06	3.55	7.14	1.62	8.78	5 01	7.37	2.45	0 52	0.80	39.65
1904.....	1.00	0.65	2.10	2.00	4.72	4.92	5 60	4.90	4.20	7.44	0.10	0.90	38.53
1905.....	1.60	1.00	1.01	T.	5.90	7.05	2.65	7.40	2.30	3.15	1.06	0.50	33.62
1906.....	3.00	T.	1.20	2.25	8.44	4.45	1.95	5.63	4.91	3.51	1.68	1.80	38.82
1907.....	3.14	1.60	2.21	1.26	1.70	6.24	3.30	4.71	5.06	1.10	1.00	0.30	31.62
1908.....	0.91	1.80	1.50	5.45	2.75	9.32	1.60	1.50	1.20	1.03	1.08	1.20	29.34
1909.....	0.60	2.80	0.40	2.81	2.56	4.77	4.96	3.50	4.29	2.94	4.56	1.15	35.34
Means..	1.17	1.24	1.66	2.74	4.55	4.71	4.06	3.65	3.77	3.44	1.33	1.67	33.99

NOTE—Observations at Menomonie from January, 1891, to February, 1895; at Knapp from January, 1898, to June, 1902; at Downing from July, 1902, to December, 1909.

Barron, Barron County, Wis.

(Elevation, 1,115 feet.)

1891.....	....	....	....	....	....	2.68	1.86	1.42	1.46	1.90	0.70	4.52	.....
1892.....	0.26	1.73	0.98	2.29	7.03	7.44	4.61	3.94	1.77	1.80	1.04	0.71	33.60
1893.....	1.23	2.91	1.75	4.91	3.85	1.25	3.28	3.66	2.85	3.40	....	2.05	.....
1894.....	1.68	0.45	2.44	4.64	8.94	2.01	2.40	1.30	1.85	4.73	1.40	1.24	33.08
1895.....	0.83	0.60	0.48	1.68	3.63	4.87	4.93	1.78	3.90	0.26	0.80	1.66	25.42
1896.....	1.63	....	....	....	....	....	....	....	....	....	....	....	.....
1897.....	2.03	1.75	2.60	1.86	2.17	6.23	5.54	1.25	2.93	1.85	0.29	0.30	28.80
1898.....	0.25	1.83	1.80	1.02	4.40	2.27	1.90	2.51	0.98	4.64	1.00	T.	22.60
1899.....	0.45	1.16	3.30	1.73	3.15	7.00	2.00	5.87	0.65	4.26	0.95	2.02	32.54
1900.....	1.16	....	1.19	1.11	1.71	2.20	7.70	7.64	....	5.40	1.00	1.05	.....
1901.....	0.49	0.50	3.50	2.22	1.82	5.23	5.10	1.70	6.55	1.28	1.50	0.40	30.20
1902.....	1.50	0.26	0 86	2.06	3.63	4.39	3.65	1.09	2 39	0.68	4.30	1.37	26.18
1903.....	0.59	0.40	2.52	2.44	5.86	3.04	6.55	4.75	5.95	3.20	0.50	0.54	36.34
1904.....	1.25	1.40	1.14	2.20	6.55	8.45	6.15	5.51	6.76	5.61	T.	0 90	45.92
1905.....	1.50	0.50	0.47	1.00	4.50	13.70	3.50	8.50	3.70	2.40	2.70	T.	42.47
1906.....	3.20	0.40	1.00	2.58	7.45	3.84	2.40	2.92	2.08	1.20	0.43	1.00	28.50
1907.....	1.30	1.05	1.08	0.70	1.83	3.39	2.75	2.50	3.75	....	....	....	.....
1908.....	0.50	1.00	1.75	4.05	3.85	5.64	2.56	1.61	1.46	3.08	0.95	0.87	27.32
1909.....	0.35	1.35	0.80	3.61	2.60	2.56	2.96	4.08	4.27	2.54	4.48	1.24	30.84
Means..	1.12	1.08	1 63	2.36	4.29	4.79	3.88	3.45	3.14	2.84	1.38	1.17	31.13

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Red Wing, Goodhue County, Minn.

(Elevation, 708 feet.)

Year.	January	February	March	April	May	June	July	August	September	October	November	December	Annual
1885.....	.....	.....	0.54	3.09	1.89	4.62	5.99	2.70	4.43	1.62	0 44	0.81	.....
1886. ...	5.25	0.65	1.36	4.68	1.45	3.23	1.50	4.51	4.99	2.58	2 29	1.18	33.67
1887.....	1.22	1.71	0.43	2.52	0.99	5.24	3.58	6.70	5.04	1.58	0.73	3.67	33.41
1888.....	1.45	0.91	3.35	4.92	7.53	3.01	3.30	3.34	1.32	1.63	0.24	0.98	31 98
1889.. ..	0.80	0.54	0.51	1.35	1.85	3.01	2.23	3.96	1.45	0.02	1.32	1.94	18.98
1890.....	1.36	0.53	0.98	1.87	4.55	8.03	1.80	3.96	3.15	3.38	0.72	0.15	30.48
1891.....	2.06	1.66	2.04	2.25	1.46	6.36	2.77	3.13	1.23	1 64	0.86	4.60	30.06
1892.....	0.17	1.90	0.87	1.09	6.06	7.44	7.17	1.80	3.38	1.18	0.40	0.66	30.42
1893.....	0.92	2.84	2.31	4.14	2.17	2.28	2.63	2.18	2.50	1.60	0.45	3.15	27.17
1894... .	0.90	0.35	1.10	3.30	2.71	2.61	0.10	1.45	2.54	5.12	0.40	0.95	21.53
1895.....	1.30	0.80	0.20	1.75	4.25	3.72	3.60	1.84	3.92	0.18	1.62	0.60	23.78
1896.....	0.97	0.20	0.20	4.56	4.10	2.98	1.31	1.55	2.79	2 73	3.10	0.95	25.44
1897.....	2.00	0.95	2.50	1.14	1.54	4.29	4.51	3.29	5.09	4.51	1.78	0.30	31.90
1898....	0.32	1.50	3.22	1.38	3.08	2.07	3.01	3.80	0.48	5.25	2.76	0.00	26.87
1899.....	2.25	4.39	1.95	0.71	4.16	6.60	1.93	4.50	1.50	4.20	0.88	1.12	34.19
1900.....	0.79	1.21	1.09	1.83	0.26	1.57	4.43	3.56	6.70	3.21	1.33	0.75	26.73
1901.....	1.00	0.69	1.79	0.85	1.12	5.42	1 94	3.74	7.28	1.56	0.62	0.61	26.62
1902.....	0.46	0.69	0.90	2.36	6.75	2.29	8.72	4.36	4.01	2.62	4.02	1.56	38.74
1903.....	0.22	0.59	0.73	1.70	8.44	0.41	3.38	4.40	11.74	1.80	0.22	0.53	34.16
1904.....	0.31	0.63	1.09	0.88	3.29	5.04	4.56	3.52	4.57	6.30	0.00	1.32	31.51
1905.....	0.81	1.03	1.74	0.23	5.46	7.40	3.64	8.71	1.94	3.08	2.24	0.30	36.58
1906.....	1.86	0.25	2.22	2.10	7.41	3.15	3.60	4.30	2.16	2.44	2.54	1.20	33.63
1907.....	1.30	1.10	0.61	1.66	0.81	4.05	3.26	7.57	6.54	0.84	0.96	0.48	29.18
1908.....	0.26	0.98	1.68	4 10	6.08	9.10	3.60	0.76	2.06	3.68	0.82	0.80	33.92
1909.....	1.30	1.34	0.77	2.54	3.34	4.40	1.86	1.78	7.38	1.98	5.50	1.44	33.63
Means..	1.22	1.14	1.38	2.28	3.63	4.34	3.37	3.65	3.94	2.59	1.45	1.20	30.19

NOTE—From November, 1896, to December, 1900, inclusive, except January and February, 1908, the records are from the river observing station at Red Wing.

Eau Claire, Eau Claire County, Wis.

(Elevation, 800 feet.)

1891.....	.....	2.95	1.85	1.70	2.00	5.40	2.20	1.70	1.07	3.10	0.70	4.65	.....
1892.....	0.30	1.60	1.00	2.40	6.15	9.10	.....	.....	2.90	1.70	0.75	1.00	.....
1893.....	1.31	2.70	1.90	5.90	4.87	0.66	2.73	1.77	2.21	3.26	1.30	5.10	33.71
1894.....	1.30	0.90	2.03	2.92	6.62	.....	.....	.....	.....	2.90	1.23	1.09	.....
1895.....	0.98	0.44	0.22	1.67	1.17	5.60	4.13	1.28	4.06	0.56	1.83	0.90	22.84
1896.....	1.40	0.40	0.60	6.35	4.50	6.25	2.67	3.00	3.03	3.00	3.70	0.50	35.40
1897.....	2.00	2.75	4.10	1.16	3.65	5.05	3.26	3.20	2.10	2.49	0.92	0.72	31.40
1898.....	0.32	2.26	2.85	2.22	1.96	1.50	1.27	0.23	0.77	5.13	1.79	0.27	20.57
1899.....	0.98	1.47	2.90	1.58	8.47	7.02	1.62	7.67	3.23	3.61	0.67	2.20	41.42
1900.....	1.00	1.49	1.23	2.95	0.75	1.86	8.88	3.37	8.73	9.41	1.32	1.00	41.99
1901.....	0.56	0.63	3.58	1.45	2.26	6.47	4.01	2.06	5.71	4 64	0.54	0.55	32.46
1902.....	0.77	0.88	1.51	3.49	5.27	2.27	5.91	3.25	2.21	2.58	4.28	3.05	35.47
1903	0.32	0.87	2.10	3.72	7.03	2.44	8.78	5.09	9.12	1.99	0.65	0.84	42.95
1904.....	0.31	0.75	1.65	1.31	2.52	7.17	2.42	2.76	3.66	5.46	0.24	1.68	29.93
1905....	0.73	0.49	2.28	0.51	6.61	6.59	2.46	6.82	4.43	3.68	1.33	0.31	36.24
1906.....	2.24	0.32	3.07	1.52	7.20	3.47	3.10	3.61	4.13	2.79	2.75	1.33	35.53
1907.....	1.85	0.75	1.95	1.20	3.27	3.80	1.12	5.68	3.65	0.77	1.33	0.42	25.79
1908.....	0.58	0.97	2.63	3.46	5.64	6.32	2.28	1.74	2.91	1.56	0.98	1.07	30.14
1909.....	1.03	1.61	1.28	3.42	3.00	2.96	2.20	2.22	6.84	2.63	5.42	1.46	34.07
Means..	1.00	1.28	2.04	2.58	4.37	4.66	3.47	3.26	3.93	3.22	1.67	1.48	32.96

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These tables show the actual amount of precipitation for each month at the various stations for the past 15 to 20 years, and also the annual amount for each of the years, as well as the mean monthly and mean annual precipitation for the period.

The amount of rainfall during the growing season exerts the most influence on growing crops. The mean rainfall for the growing season and also the non-growing season is shown in the following table:

TABLE VI.—*Mean monthly precipitation for the growing and non-growing season for the entire period of record of each station, to 1909.*

Month.	Grantsburg.	Osceola.	Barron.	Downing	Eau Claire.	Red Wing.
April	2.78	2.33	2.36	2.74	2.58	2.28
May	4.11	4.27	4.29	4.55	4.37	3.63
June	4.80	4.75	4.79	4.71	4.66	4.34
July	4.40	4.12	3.88	4.06	3.47	3.37
August	3.45	3.28	3.45	3.65	3.26	3 65
September	4.18	4.05	3.14	3.77	3.93	3.94
Mean of the growing season	23.72	22.80	21.91	23.48	22.27	21.21
October	2.70	2.95	2.84	3.44	3.22	2.59
November	1.44	1.39	1.38	1.33	1.67	1.45
December	1.23	1.17	1.17	1.67	1.48	1.20
January	1.11	1.00	1.12	1.17	1.00	1.22
February	1.11	0.92	1.08	1.24	1.28	1.14
March	1.75	1.90	1.63	1.66	2.04	1.38
Mean of the non-growing season	9.34	9.33	9.22	10.51	10.69	8.98
Mean annual	33.06	32.13	31.13	33.99	32.96	30.19

The mean annual rainfall varies from 30.19 to 33.99 inches at the several stations. During the growing season from April to September the amount of rainfall is from 21.21 to 23.72 inches, the greatest fall occurring in May, June, and July, when most needed by the growing crops.

The amount of precipitation in the non-growing season from October to March, varies at the stations from 8.98 to 10.69 inches, being less than one-half the amount falling during the growing season. A little more than two-thirds of the annual rainfall, therefore, falls in the growing season. The monthly precipitation at Eau Claire and Osceola is illustrated in the diagram, fig. 13.

While the mean annual rainfall is generally from 30 to 33

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inches there are occasional dry years when there is much less precipitation. During the 10 year period from 1893 to 1903, the precipitation during the driest year was 20.6 inches at Eau Claire and 27.1 inches at Barron, and during the wettest year of this 10 year period, there was a rainfall of 42.7 inches at Eau Claire and 36.3 inches at Barron. The records appear to show that the annual rainfall in the northeastern part of the area is more uniform from year to year than in the southwestern part.

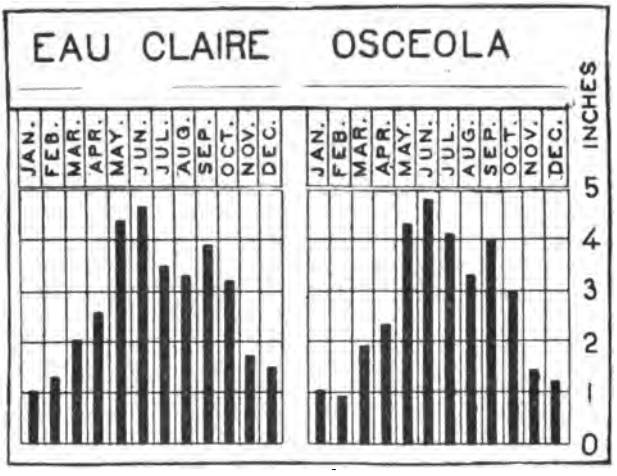

FIG. 13.—Diagram showing monthly precipitation at Eau Claire and Osceola.

It is of interest to compare the mean seasonal rainfall and mean seasonal temperatures of the area with that of the entire state and the adjoining states, as shown in the following table:

TABLE VII—*Table showing seasonal rainfall and temperatures.*

	Spring.		Summer.		Autumn.		Winter.	
	Mean temp. deg.	Mean precip. inches.	Mean temp. deg.	Mean precip. inches.	Mean temp. deg.	Mean precip. inches.	Mean temp. deg.	Mean precip. inches.
Northwestern Wis....	42.	8.6	67.3	12.6	46.1	7.9	13.7	3.7
Wisconsin.....	43.	8.3	68.0	11.2	47.	8.1	17.	3.9
Iowa.....	47.4	8.8	71.8	12.2	50.1	7.1	20.2	3.3
Northern Ill.....	48	9.5	72.	10.6	52.	8.3	23.	5.6
Northern Ind.....	49	9.9	72.3	10.4	52.9	9.2	26.	7.5

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The summer months are the most important agriculturally and the table shows that for the summer season the mean temperature of the area is very favorable for agriculture, and is only a few degrees colder than the temperature of Northern Illinois, Northern Indiana, and Iowa and that the rainfall during the

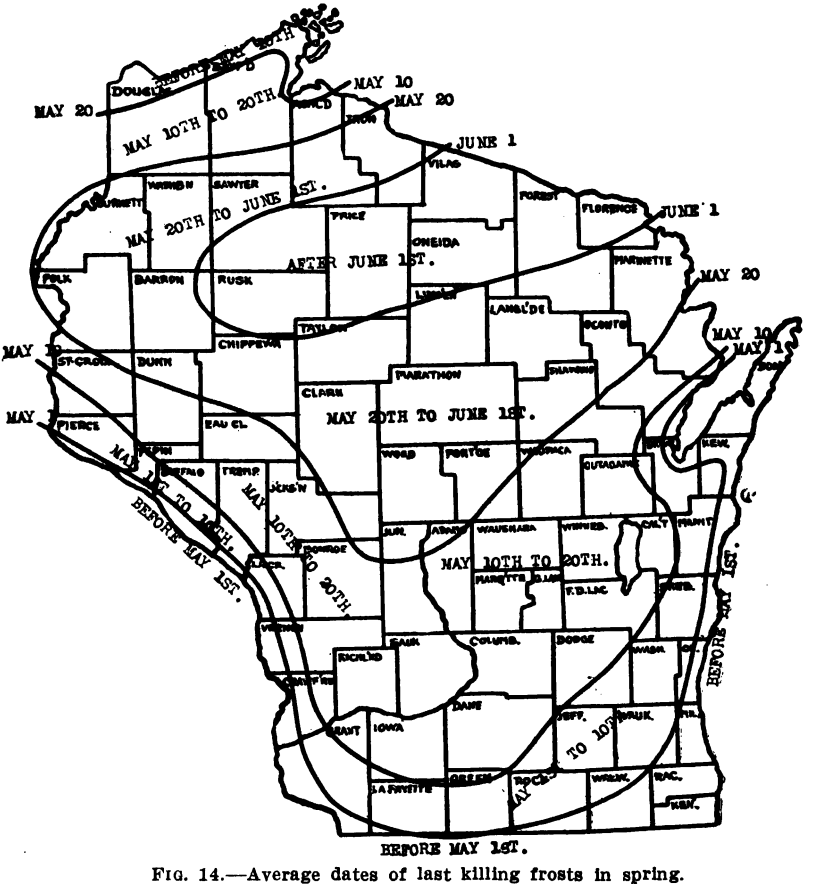

FIG. 14.—Average dates of last killing frosts in spring.

summer is more favorable than in the latter regions. The table shows that while the summer temperatures of the area closely approaches that of the region farther south, the winters are considerably drier, and colder than in the latitude of Northern Illinois.

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TABLE VIII.—*Frost data.*

Stations.	Length of record, years.	Average date of	
		Last killing frost in spring.	First killing frost in autumn.
Barron	18	May 22	September 15
Grantsburg	17	May 14	September 19
Osceola	19	May 12	September 26
Downing	15	May 6	September 24
Eau Claire	19	May 10	October 1
Red Wing (Minn.)	8	May 2	October 5

Killing Frosts. The average date of last killing frost in the spring and first killing frost in the autumn is shown in the above table, complied from records extending over a period of 19 years.

The average period of immunity from frost at Barron is 115 days, at Grantsburg, 127 days, at Osceola, 134 days, at Downing, 140 days, at Eau Claire, 142 days, and at Red Wing, 155 days. The average period of immunity from frost in Rusk county is probably between 105 and 110 days, and in Pierce and Pepin counties about 150 to 155 days. In the two charts* of the state, figures 14 and 15, the several zones having similar frost data in the Spring and Autumn, are illustrated.

This period is sufficiently long for the growth of all common crops, with the possible exception of corn in the northeastern part of the area. In the northern part of Barron, and in Rusk, probably only the Wisconsin No. 8 variety of corn and flint can generally be brought to maturity. Corn for silage, of course, can be grown successfully in all parts of the area.

Other crops that are likely to be affected by the frost are tobacco and potatoes. Potatoes readily ripen within the period of 100 days or less. Tobacco is successfully grown in Chippewa and Barron counties. Tobacco, with proper rainfall and warm temperature conditions, will ripen in 70 to 80 days.

The tables of temperature and rainfall of the several stations furnish the detailed climatic data for the North Western area. It should be borne in mind by the farmer that the condition of

* Bartlett, in Bulletin 290, University of Wisconsin.

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the soil is only one factor in the problem of agriculture and that conditons of temperature and amount of ranfall, especially for the growing season are also very important factors. The

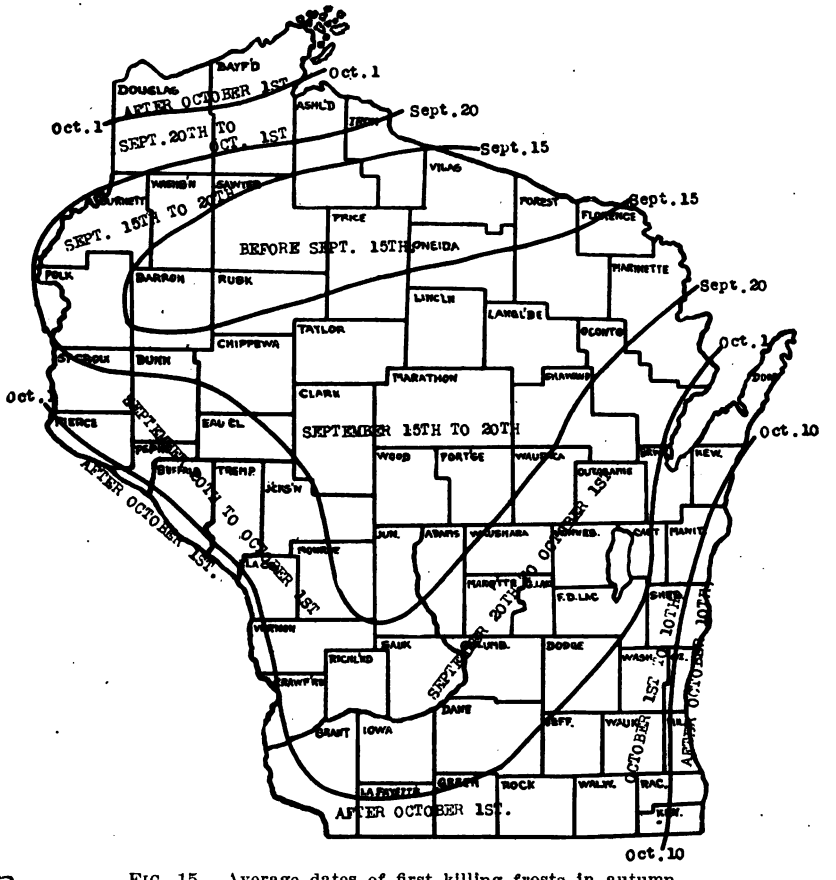

FIG. 15.—Average dates of first killing frosts in autumn.

kind of crop raised should be especially studied with respect to its climatic requirements, and comparisons should be made with the known conditions under which such crops have been grown in other localities.

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CHAPTER III.

DESCRIPTION OF THE SOILS.

In the 6700 square miles of the area, there are fourteen kinds of soil as shown on the map. (Plate I in pocket.) Some of the soils are quite uniform in character over large areas while others are quite variable and lack uniformity.

Character and Origin of Soil.—The soil consists of mineral and organic material. The mineral portion of the soil originates through the disintegration and weathering of the stony material and the surface formations of the land, and the organic portions through the decay of animal and vegetable matter living upon and within the soil.

The most effective agent in the weathering of soils is water in its various forms, the changes of temperature, and the air. Water in the soil aids chemically by dissolving mineral matter, and mechanically by washing and wearing away loose soil material. The alternate freezing and thawing of water in the soil and rocks, in autumn and spring tend to break up the soil particles. Earthworms and other burrowing animals, aid materially in making soil. The growth of roots of the forest trees and also the smallest plants tend to split apart the rock particles and assist in soil formation.

Soil Erosion.—There is a constant process of wash by rains of the loose soil material from the higher levels and slopes of the hill sides to the valley bottoms, and thence by streams to still lower levels down the valleys. If rains are gentle, but little soil is washed away, but if rains are heavy, they may transport in a few hours enormous amounts of sand and mud to lower levels.

But little erosion can take place on nearly level or gently undulatng lands, but where slopes are steep the various bad features of erosion may develop. The lighter and more sandy soils, into which the rains can readily penetrate are not likely to be

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appreciably eroded, even on the sloping lands, while the heavier clay soils and loams, unless carefully guarded may be subjected to much erosion. Most of this area on account of the loamy character of the soil and the gentle slope of the land is not likely to be much eroded, but in certain hilly portions, in the southwestern counties, the tendency to soil erosion should be checked as much as possible.

Sources of the Soils.—The soils have their source in the slow weathering and decomposition of the various formations of the area, such as the glacial drift, the loess, the alluvial plains, and the sandstone, the limestone and the crystalline rocks. The most important formations from which the soils are derived, are the surface formations of drift, loess and alluvial material, as these formations generally cover the bed-rock formations. In certain parts of the area, however, soils derived directly from the sandstone cover considerable areas. In the areas of the limestone and crystalline rocks, however surface formations of loess or drift are generally present. However the character of the surface formation is often largely determined by the underlying rock and hence the various geological formations are important factors in determining the character of the overlying soil.

Surface Soil and Sub-soil.—The surface soil generally containing more or less organic material, usually extends to depths of 6 to 8 inches. The subsoil immediately below the surface soil is important as the medium in which much of the soil moisture is stored. If the subsoil is such as to hold too little or too much moisture, the fertility of the soil is greatly decreased. It is important to know the character of the soil to a depth of 3 or 4 feet below the surface as well as of that portion which is turned by the plow.

Basis of Soil Classification.—The classification of soils and their separation and mapping into various types or phases, is based on the physical texture of the soil mainly due to the relative proportions of sand and clay present. Soils are generally referred to as clays, loams, or sands. A clay soil generally contains from 25 to 50 per cent of clay and the remainder silt, sand or gravel. A loam generally contains from 10 to 25 per cent of clay, a large proportion of silt and the remainder fine to coarse sand or gravel. A sand soil generally contains less than 10 per

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cent of clay, a small amount of silt, and a large amount of fine to coarse sand. Between clays, loams and sands are many gradations such as phases of clay loams, silt loams and sandy loams. If a considerable amount of stone or gravel is present the soil is called stony or gravelly. Besides these soils there are the muck and peat soils containing a high percentage of decaying organic matter or humus, occuring in swamps and marshes.

Chemical Composition of the Soil.—The various chemical elements occuring in soil are oxygen, silicon, carbon sulphur, hydrogen, chlorine, phosphorus, nitrogen, fluorine, boron, aluminum, calcium, magnesium, potassium, sodium, iron and manganese. The oxygen hydrogen, carbon, chlorine, and nitrogen get into the soil from the atmosphere and the rains assisted by vegetation. The other elements are found in the rocks and surface formations from which the soils are derived. All the above named elements are generally in sufficient quantity to supply the required plant food, for crops. Only four of the elements, potassium, phosphorus, lime and nitrogen are generally considered important in the study of the soil fertility because these elements sometimes may be either lacking in sufficient quantity, or are not in an available form to supply plant food.

The names adopted for the various soil formations are local and have been selected from the names of rivers or townships where the soils occur, within this area, and within the area of north central Wisconsin immediately to the east.

The following table gives the approximate extent of the various soils mapped in the area:

TABLE IX.—*Areas of the soils.*

Soil.	Acres.	Soil.	Acres.
Chelsea loams	788,000	Chetek sandy loam	230,000
Hartland silt loam	556,000	Cushing loam	216,000
Auburn loams	482,000	Sterling sand	189,000
Baldwin silt loam	341 000	Swamp and marshland	160,000
Rice Lake loams	328,000	Milltown silt loam	69,000
Colby silt loam	323,000	Thornapple sandy loam	65,000
Kennan silk loam	316,000	Meridean sandy loam	44,000

Of the fourteen soils, seven are soils derived from the weathering of glacial drift, and physiographically are upland soils. The drift soils include the Colby silt loam, Chelsea loam, Kennan silt loam, Cushing loam, Thornapple sandy loam, Milltown silt

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loam, and Baldwin silt loam. Other upland soils are the Auburn loam, developed mainly as residual soil on the sandstone and shale, and the Hartland silt loam developed on the loess. The soils which are of alluvial origin and mainly confined to the valley bottoms are the Rice Lake loam, the Meridean loam, the Chetek sandy loam, and the Sterling sand. Muck is characteristic of the marsh and swamp lands.

BALDWIN LOAMS.

Area.—The Baldwin loam occupies the central and eastern part of St. Croix county, and the adjoining northern part of Pierce county, and in general is developed over the limestone formations. It embraces a contiguous area of about 550 square miles, located in the most thickly populated portion of the region.

Surface.—In general the surface of the Baldwin loam is gently undulating with long gentle slopes. Considerable tracts are nearly level in eastern St. Croix county, in the towns of Springfield and Baldwin. The surface is gently undulating in Hammond, Erin Prairie and Emerald, with occasional lakes and ponds. In Gilman, Martell and Pleasant Valley the land varies from gently rolling to nearly level, with gentle slopes characterized by wet lands with poor drainage along the large streams and their many small tributaries. These small areas of wet lands along streams are found in nearly all the townships. In Eau Galle broad valleys, sloping gently upward to the higher land, are characteristic.

The area of this soil is mainly drained by the Eau Galle, Rush and Kinnickinnic rivers. In St. Croix county these streams flow through the broad uplands but further south in Pierce county they become trenched deeply into the limestone formations, first with narrow valleys and then farther south with broader valleys widening out to a mile or more. The Kinnickinnic river in the town of Kinnickinnic and River Falls has a broad valley bottom containing highly developed agricultural areas.

While no peat marshes of any size are associated with this type a conservative estimate of the area that would be benefitted by drainage exceeds 15 or 20 per cent. In the town of Eau Galle and Springfield and southern Baldwin considerable areas of wet lands are found. Boulders are found in the soil throughout

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the area. In few cases, however, are the boulders so abundant as to interfere seriously with agriculture. Where the country has been opened for settlement some time the stone has been hauled off from the cultivated fields.

Forests.—The Baldwin loam was covered with dense forest in the eastern part of its area, and with meager forests in the northwestern part. In the densely wooded portion the trees were mainly hardwoods, consisting largely of maple, white oak, black oak, basswood, elm, ironwood and butternut. In the valleys, or wet lands, ash, soft maple and elm predominate. Here and there, however, on the upland slopes and in the valleys were tracts in which white pine was predominant. A belt, nearly two miles wide, between Woodville and Brookville was one of the largest of these pine tracts.

The pine has been wholly cut for several years. Considerable stands of dense hardwoods, however, still remain. Most of the 60 per cent of undeveloped land of this soil type in the towns of Cady, Eau Galle and Gilman, is still covered with forest.

In the towns of Hammond and Erin Prairie and vicinity were large tracts covered only with a meager forest growth consisting mainly of scrub oak, poplar, and hazelwood. These tracts were generally known as "prairies" and were the first lands in the region to be opened up to agriculture. In a few places only are there remnants of these thinly forested tracts. At present from 80 to 90 per cent of these thinly forested tracts are under cultivation.

Soil.—In general the surface eight inches of the Baldwin loam is a silt loam or loam with sufficient amount of organic matter to give it a medieum dark brown color. This type is found over a large part of the area of Northwestern Wisconsin, mainly on the higher land as distinguished from the areas nearer streams and along slopes.

The subsoil from eight to twenty-four inches is usually a fine grained sandy loam. In places the subsoil is bluish in color where the underlying limestone is Trenton, and in such places it is quite retentive of moisture. At lower depths gravelly material is associated with much of the soil. The peculiar structure of the subsoil in places where Trenton shale is present gives rise to some important problems of drainage which will be discussed in another place. Underlying this loam is mainly a lime-

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stone bed rock. In portions of Pierce county, mainly in River Falls and Martell, and in St. Croix county, in Kinnickinnic and Troy this limestone is the Trenton formation. In the remainder of the area, with a few exceptional areas of sandstone, the underlying rock is limestone of the Lower Magnesian formation.

There are slight variations of this soil which differ from the dominant type just described.

A portion of the Baldwin soil area has been designated as a prairie though it differs essentially from a true prairie in the absence of black prairie soil. A true prairie soil contains a relatively large amount of organic matter, as can be observed by the black color of soil to considerale depths of five or twenty feet, or even more. This black organic matter represents past accumulation of prairie grass and other vegetation that has grown up and accumulated in the soil there to decay during long periods of time. Rainfall is an important factor, and also topography, in developing a prairie vegetation. When rainfall exceeds 25 inches the native vegetation tends more to develop light forest growth and consequently less grass vegetation.

The surface soil on the openings or "prairie" tracts is medium heavy loam carrying small amount of coarse gravelly particles. It has a grayish to dark gray color with a fair amount of organic matter as indicated by chemical analyses. The subsoil becomes somewhat more clayey at about two feet, and is usually of yellowish color. The organic content in the surface eight inches in the so-called prairie of Hammond and Erin Prairie, as shown by chemical analysis, is practically the same as in the heavily forested soil in Springfield and Eau Galle. Below 22 to 24 inches the soil in most cases becomes somewhat gravelly in places but the clay content with it makes the soil at the lower depth more compact.

The content of medium and fine sand in this soil makes it fairly loose and open, yet some areas show that tile drainage is needed to remove surplus underground water. This is especially true where the land is nearly level.

Aside from the marshy tracts, there is perhaps no section within this area described in this report where necessity of drainage is of so much importance as in this section. Surface ditching would be a considerable help in many areas but eventually tile drainage must be resorted to. Up to the present time little

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has been attempted in the way of tiling. Many farmers are in doubt as to the efficiency of tile drainage, fearing that the heavy subsoil would prevent downward passage of water fast enough or that the tile will fill up and hence be of no value. General practice elsewhere has long demonstrated the great value of tile drainage.

In speaking of drainage it is the popular notion generally that only low lands and marshes are areas most in need of drainage. In this area much of the land requiring drainage is upland, some even on highest table land, where the fall for natural drainage would ordinarily be sufficient. The subsoil, however, in these wet upland tracts is usually the tenacious Trenton clay already referred to. When this clay becomes thoroughly wet it is impervious, causing water-logging of soil at the surface.

The results of mechanical analyses of composite samples of the soil and subsoil are shown in the following table:

TABLE XI.—*Mechanical analysis of the Baldwin silt loams.*

No.	Location.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
130	Springfield, St. Croix Co....	Soil..	.0	6.2	5.9	9.4	12.8	55.4	9.9
130	Springfield, St. Croix Co....	Subsoil..	.3	10.6	11.5	17.2	11.2	38.0	11.0
122	Eau Galle, St. Croix Co....	Soil..... ..	.0	8.8	9.11	13.1	12.5	45.7	10.3
122	Eau Galle, St. Croix Co.....	Subsoil...	.4	9.0	11.7	15.4	15.4	32.5	15.2
125	Erin Prairie, St. Croix Co.....	Soil..	.0	6.9	8.9	11.0	15.5	48.0	9.3
125	Erin Prairie, St. Croix Co....	Subsoil...	.3	7.9	20.0	16.4	15.0	32.4	16.0

Agriculture.—The crops raised are very largely oats, wheat, some barley and flax. Wheat is important only in Hammond, Erin Prairie, and adjacent territory. Corn is raised mainly in western St. Croix and on the uplands in Troy, Kinnickinnic in northern Pierce county. In the remainder of area the corn acreage is considerably less. The leading exports from the farm consist of dairy products and live stock, mainly hogs, beef cattle, and sheep. The dairy product is mainly cream which is usually collected and sent to local creamery, run on a co-operative basis. The Baldwin co-operative creamery is one of the largest in the state.

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In Rush River and Pleasant Valley are areas of sandy loam of limited extent. This soil with its large area of slopes is well adapted to grazing and pasture. The Baldwin loam is well adapted for dairying and sheep raising. Fifty per cent of the wool raised in northwestern Wisconsin is raised on the Baldwin soil. Pasture lands are well watered as a rule and retain good feeding ground even during dry seasons. Large tracts are devoted to hay, timothy, redtop, and some clovers.

The grain and hay is generally fed on the farms. Corn has not been extensively grown but a variety like Wisconsin No. 8 ought to be tried. The average period of immunity from frost is 135 to 145 days in Pierce and St. Croix county. There is no question but what corn would mature. Dairy farmers will also soon find corn silage an excellent feed for dairy stock. More attention should be given to proper rotation of crops on this soil. Hay fields in which timothy was grown for three to five years were common. When this old sod is plowed again the physical condition of the soil is far from what it should be. After lying so long in sod a good application of farm manure is needed to develop sufficient fertility to produce a good grain or corn crop.

A good rotation is to include clover or alfalfa in the rotation either alone or with red top and timothy and allow these crops to occupy land not longer than two years out of a possible four or five year rotation. In connection with growing alfalfa it might be mentioned that when farmers have difficulty in obtaining a stand it is due probably to lack in the soil of the bacterial organism which causes the formation of tubercles or nodules on the roots. The soil in such cases requires inoculation from fields where alfalfa is growing. When this is impossible inoculation by scattering soil from the sweet clover plant does equally well. The organisms from alfalfa and sweet clover are identical. Sweet clover grows along the roadsides as a tall, rank weed with whitish blossom. Around Centerville, and also near Beldenville areas of sweet clover were observed.

Ground limestone at the rate of 2000 pounds per acre will be beneficial on many of these soils where soil acidity has developed, the acidity being shown by the development of a rather healthy growth of yellow sorrel and sheep sorrel. When ground limestone is unobtainable, unslaked lime will do equally well.

The application of limestone and phosphate fertilizer where

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needed together with the very general growing of leguminous crops and the application of stable manure applied directly from the stable and a proper rotation of crops will maintain fertility of the soil as well as insure profitable crop yields.

The so-called "openings" or "prairies" in Hammond and Erin Prairie have been and are still the most important grain raising sections in the region. When first opened to agriculture, wheat was about the only crop harvested and sold from the farm. About 1890, however, a change came about and less wheat was sown, partly due to decrease of yield and partly to ravages of the chinch bug. During the last 15 years there was a tendency to grow more of the other grains and a rotation including oats, barley, and wheat in order named became the system. At present this order of farming still applies to the town of Erin and to a smaller degree elsewhere. At present the tendency elsewhere is away from the exclusive grain farming and towards a diversified farming instead. Corn is becoming more important and stock is raised for dairy and beef purposes.

The farmers have learned from experience that an exclusive grain farming system which does not involve the return of abundant fertilizing material during course of rotation, has lowered the yield per acre so much that in some instances the crop did not pay for the labor expended in caring for it. With a more systematic rotation, including the more general growing of clover and application of farm yard manures the yield per acre has been perceptibly increased.

The ideal system of farm practice requires the keeping of considerable stock and the maintenance of a balanced system of rotation of crops in which some grains, wheat or oats, flax, etc., and clover would be included. The farm products exported would consist mainly of cream, butter, or fat stock. Even when grain is largely the important crop exported, the fertility of the soil and production per acre can also be maintained. Such a system would involve a rotation of crops in which clover would occupy land at least one-quarter of the rotation period, and a generous application of manure and lime or phosphate occasionally when needed. Where grain raising is the principal industry and where, as shown by experimentation, a phosphate fertilizer is needed to increase the yield the phosphate should be applied to the soil in combination with stable manure. The

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manure will aid greatly in making the phosphorous available. The organic matter in the soil also acts similarly to manure in gradually liberating the phosphorous in the fertilizer. Where the phosphate fertilizer is found to be beneficial, applications of about 1000 pounds of ground rock phosphate per acre followed by lighter application of 200 to 300 pounds during each rotation period is generally found to be sufficient. The supply of nitrogen to the soil can be maintained as already stated by the growth of leguminous crops.

Land Values.—The usual price of improved land on this soil type is $60 to $100 per acre, and occasionally higher prices. As a rule farms devoted to grain raising bring lower prices than those devoted to dairying and stock raising.

COLBY SILT LOAM.

Area.—This soil formation occupies a large part of Barron county, with small areas in adjoining counties. In Chippewa county in the vicinity of Stanley and Boyd is a considerable area of this soil formation. This soil has an area of 525 to 550 square miles, 85 per cent of which is within Barron county. It has also a wide extent farther east, in Clark, Taylor, Marathon, and Wood counties, as described in the report on the soils of North Central Wisconsin.

Surface.—The surface of this soil is gently rolling and undulating. See Plates VI and VII. Somewhat hilly areas are found adjacent to streams and rivers, as for example along the Hay river and Turtle creek, where tracts nearly one-half mile in width are quite broken and uneven. As a general rule, however, none of this land is too hilly for cultivation. The soil is generally well drained, and within its area lakes and swamps are very rare.

In many instances the very gently sloping fields would be benefited by tile drainage. While the character of the subsoil is generally favorable to natural underdrainage, yet there are exceptions where the soil remains too wet and cold during the growing season to develop good crops and in these cases tiling or other methods of farm drainage should be practiced.

Forests.—This soil was formerly forested with a heavy stand of mixed timber including maple, basswood, oak, with some elm and ash among the hardwoods, and white pine, hemlock, and

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some balsam. The pine was cut first and practically none remains at present. Among the hardwoods, considerable tracts of maple, basswood, and elm are found throughout the entire area.

Soil.—The soil of this formation to a depth of eight inches is a silt loam. It contains enough silty material to make it a quite friable and open soil. Some boulders and coarse material are associated with it. The subsoil is yellow to buff colored silt loam that becomes slightly more clayey with depth. Both surface and subsoil are quite uniform in physical character.

The following table gives the results of mechanical analyses of the soil and subsoil of this type:

TABLE XII.—*Mechanical analysis of Colby silt loam.*

No.	Location.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
154	Barron Co.....	Soil.....	.1	3.2	4.0	3.6	12.6	61.9	13.6
154	Barron Co.....	Subsoil...	.0	3.2	4.7	3.2	19.7	51.2	17.4
119	Chippewa Co....	Soil.....	.0	2.5	1.6	3.3	20.3	58.7	13.7
119	Chippewa Co....	Subsoil...	.0	0.6	.5	.7	20.5	63.5	14.0

The Colby silt loam is a glacial drift soil derived from the weathering of the old drift formations. The material of the drift consists of clay, sand, and boulders from the crystalline or granite formation and sandstone. The soil is free from debris derived from limestone formation, and in this regard differs from the Baldwin loam which contains much limestone material. While the Colby silt loam generally contains sufficient lime derived from the weathering of crystalline formation the content of lime in the soil water and in the soil itself is probably generally lower than in soils developed upon limestone drift. An acid condition, however, of this soil is of rare occurrence, at present, though acidity may develop later.

The soil bears well, is naturaly well drained on account of its rolling surface and works up easily as a rule. It is one of the most fertile soils of northern Wisconsin. It is not known to pack or become puddled after heavy rains. At the present time less than one-half of the land in farms is under cultivation, but the clearing of land for agricultural purposes is going on rapidly.

Agriculture.—Dairying is the leading industry on this soil

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VIEW OF COLBY SILT LOAM, NORTH OF CADOTT, CHIPPEWA COUNTY.
Shows general character of farm buildings developed in a dairy and general farming section.

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VIEW OF COLBY SILT LOAM, SOUTHWEST OF RICE LAKE, BARRON COUNTY.
Shows the deep, broad valleys developed in the old drift.

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type at present and will probably continue to increase in importance as the land is brought under the plow. The soil is especially well adapted to live stock. The tract furnishes abundant pasturage, and springs and streams afford plenty of water. Clover and other tame hay produce excellent yields.

Oats are the leading grain raised. Barley and wheat are grown to a small extent and give good yields. Corn has not been raised extensively on this soil, though both soil and climate are favorable. A large acreage is devoted to pasture, clover, and timothy. Potatoes are a good crop for export. Sugar beets and other root crops are grown quite extensively. The acreage of corn should be increased not alone for its value as silage and grain, but also for its value as a rotation crop with oats and the grasses.

Land Values.—The prices at which improved land is held varies from $60 to $100 per acre. Uncleared land of this type is generally held at $15 to $25 per acre. Good stands of timber still remain on large tracts of this soil type.

KENNAN SILT LOAM.

Area.—The Kennan silt loam lies in the northeastern part of Chippewa county and over a large part of Rusk county. It is mainly the gently undulating ground moraine area of the latest drift sheet. This soil type extends over a large portion of Price, Taylor and Lincoln counties as described in the soil report of North Central Wisconsin.

Surface Features.—The surface of the soil is generally rolling or slightly undulating with here and there, throughout the area, broad stretches that are quite level. Nearly all of the soil can be brought under cultivation. Large swamp and marsh areas are prominently associated with this type in portions of Rusk county. Nearly one-fourth of some of the towns in Rusk, as indicated on the soil map, are marsh and wet soil. The tract is drained mainly by the Chippewa and Flambeau rivers. See map of eastern part of Rusk county, figure 16.

Native Forest.—This silt loam developed some of the finest stands of hardwoods in the state. Pine was not relatively abundant, but considerable hemlock was interspersed with the hardwood. Cedars are common along low river areas.

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At present but little of the original forest remains. The pine has been wholly removed, and at present the hemlock and hardwoods are being rapidly cut out. Forest fires have caused much damage in places. The wooded section of northeastern Rusk county suffered especially from wind storms, at an early date as indicated by numerous tracts of windfalls. Large mills for sawing hardwood and hemlock are located at Atlanta, Ladysmith, Ingram, Hawkins, Ruby, and Arnold.

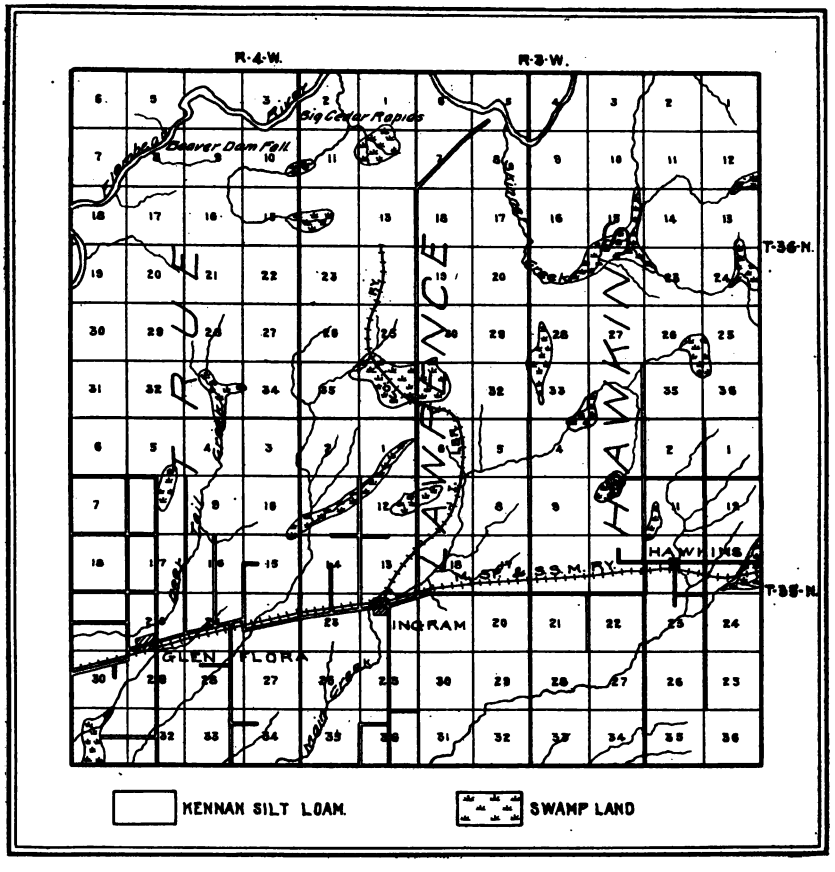

FIG. 16.—Soil map of northeastern Rusk county.

Soil.—The surface soil to depth of eight inches is a silt loam, somewhat grayish in color and quite free from stone. The subsoil is silt loam, carrying considerable clay. As shown by mechanical analyses most of the soil is very fine sand, silt and clay.

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Both surface and subsoil are quite uniform over the area. Some stone occurs in the soil and in some places interferes with agriculture. These stony areas are found in low places or bordering marshes, and in a few cases on the uplands. Some of the soil on the gentle slopes will require tile drainage to get the best crop results.

The results of the mechanical analyses of samples of the soil and subsoil are shown in the following table:

TABLE XIII.—*Mechanical analyses of Kennan silt loam.*

No.	Location.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
120	Chippewa Co.....	Soil.....	.0	2.5	1 8	3.0	18.5	60.3	14.7
120	Chippewa Co.....	Subsoil...	.0	.7	.7	1.3	29.1	52.6	15.4
165	Rusk Co.....	Soil.....	.1	2.3	2.4	4.0	12.1	67.7	11.2
165	Rusk Co.....	Subsoil...	.2	1.9	2.2	3.6	25.1	55.3	11.5

Agriculture.—This soil area is opening up and developing rapidly into a typical dairy section, for which purpose it is well adapted. The grasses grow exceptionally well, especially clovers, timothy, and red top. The many streams furnish abundance of water for stock. Common wells 15 to 30 feet deep furnish a supply of water for the home. Blooded stock is being introduced, Holsteins and other dairy types being most prominent. Sheep have been introduced and pay well.

Small grains such as oats, and barley yield abundantly, the yield of each being 30 to 40 bushels per acre. Corn has not been grown to a large extent. With the increase in the dairy industry more corn, especially for ensilage, will be grown. Special crops like seed peas for canning purposes have been found to do well on this soil. A large farm in southeastern Rusk has been developed for growing peas for seed and canning purposes. The common pea could be successfully raised for fattening hogs and other stock in place of corn.

In Chippewa county tobacco has been grown successfully on this silt loam soil. The acreage of both the tobacco and pea crops will be materially increased in these counties in the future.

The chemical analysis of a sample of virgin soil collected from northwestern Chippewa county shows that the soil is well supplied with essential plant food elements. This should not be

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taken however, to indicate that excessive grain cropping without proper attention to rotation can be practiced on it. The present up-to-date agriculturist should profit by the experiences of others in the past and maintain the fertility of his soil.

The Kennan clay loam is very largely wild land, either thickly forested with hardwoods of cut-over land. Probably less than 5 per cent of this soil in Chippewa county is under cultivation and less than 3 per cent in Rusk.

The cost of clearing this land ranges from 15 to 30 dollars per acre, depending upon the amount of slashing and stumpage found on it. The wood not fit for lumber is usually sold as fuel to the paper and saw mills and the profit received from this source helps considerably to defray cost of clearing the land.

Land Values.—The wild land, with little or no merchantable timber, is generally held at $10 to $20 per acre, depending on location and accessibility. Cleared farms, with buildings, are generally held at $50 to $80 per acre.

CHELSEA LOAMS.

Area.—The Chelsea loams form a belt of considerable width in northeastern Chippewa county, western Rusk county, northwestern Barron county, and a large portion of Polk county. This soil type, as defined, consists essentially of undulating terminal moraine of the latest period of glacial drift. The Chelsea soil covers a large area farther east, in Taylor, Lincoln and Langlade counties, as described in the soil report of North Central Wisconsin.

Surface Features.—Because of the manner in which this soil type was formed, as glacial moraines, considerable variation in the surface features have developed. In general, the land is undulating with belts of low ridges and billowy hills, associated with basin-like depressions, swamps and small lakes and ponds. See Plate VIII. Here and there, throughout, are stretches of more level areas. The hilly land is usually more stony than the level areas, the latter usually being either more sandy or more clayey than the former.

In western Rusk and eastern Barron counties are relatively high uplands consisting of hard quartzite formations. On the slopes of these ridges there is usually much loose stone. Flambeau Ridge in northern Chippewa county is a prominent feature

VIEW OF CHELSEA LOAM, WEST OF TURTLE LAKE, POLK COUNTY.
Shows characteristic view of terminal moraine topography.

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of the topography. In the west central part of Polk county are broad upland areas of trap rocks, showing abundant outcrops of rock ledges.

Native Forest.—The Chelsea loam was originally covered with a dense growth of hardwoods, hemlock, and pine. Practically all the pine has been cut for a number of years. Large bodies of hardwoods and hemlock, however, still remain. The hardwoods were chiefly maple, oak, birch, basswood, and elm. The amount of hemlock was generally equal to or greater than the combined hardwoods.

On the lighter phases of the soil, some scrub oak was developed. In the swampy and wet tracts, spruce, ash, soft maple, and ash are common.

Soil.—The Chelsea loam varies from a sandy to silty loam in the surface eight inches, with a somewhat heavier subsoil of loam from eight to thirty inches. The surface soil is grayish to medium dark in color, and the subsoil lighter colored. The soil is not uniform over the area as mapped, but varies from a sandy loam to silt loam.

The soil is derived from the weathering of glacial material, consisting of sand, clay, and boulders of crystalline and sandstone formations. No limestone material occurs in the soil.

A detailed soil map of the area should show a complex association of sandy loam and silt loam type of soils. In some places the heavier silt loams prevail, in other places, the sandy loams.

The surface feature of the soil as already described are uneven and undulating, and the variation in the physical texture of the soil, is strongly influenced by the topography.

Stone and boulders are a common occurrence in the soil. Generally the stone is found in narrow belts and patches, and occasionally becomes a serious handicap to the development of agriculture. The low marshy areas are often quite stony.

The mechanical analysis of the soil is shown in the following table:

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TABLE XIV.—*Mechanical analysis of Chelsea loam.*

No.	Location.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
140	Polk Co.....	Soil.....	0.1	5.7	4.0	4.0	19.4	53.6	12.8
140	Polk Co.....	Subsoil...	.0	3.3	3.2	3.0	27.2	46.3	16.8
136	Polk Co.....	Soil.....	.2	7.4	4.3	4.2	14.2	57.3	11.8

Agriculture.—The soil is well adapted for certain lines of agricultural development. Chief among these is dairying together with sheep and stock raising. The rougher and more hilly portions are admirably adapted for grazing purposes. In some few localities sheep and goat raising has already assumed importance. In the newer sections sheep and young stock will be found profitable while the cultivable areas are being cleared for the plow.

Dairying is now the most important industry and will become more important in the future. Several factors are strongly favorable to dairy farming on this soil. In the first place, pasturage, as stated above, is abundant, and all grasses thrive readily. Clovers, timothy, and alfalfa do exceptionally well for hay crops.

Oats are the principal grain crop, the average yield being about 40 bushels per acre. Barley and wheat are raised to some extent. The acreage of corn has markedly increased during the last 10 years, being more than double that of 10 years ago. The average yield per acre of wheat is about 15 bushels, of rye 16 bushels, of barley 30 bushels, and corn 40 bushels. The yield of hay is generally from one and one-half to two tons per acre. Excellent potatoes are grown, the usual yield being 100 to 150 bushels per acre.

The grains and forage crops are generally fed on the farms instead of being marketed. Concentrated feed stuffs are purchased besides, especialy where the dairy business is continued throughout the year.

If the dairying system of farming continues in its rapid development, the question of maintaining the fertility of the soil will be easily solved. A low stage of fertility like that which tends to be developed by excessive grain cropping, is not likely to be developed on farms where much stock is raised and where

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VIEW OF MILLTOWN LOAM, NEAR RANGE, POLK COUNTY.
Shows typical dairy farm with buildings, including silo.

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the return of plant food to the soil is made in the form of barn yard manure.

Only a small percentage, probably less than 5 per cent, of this soil type in Chippewa, Rusk and northeastern Polk counties is opened to agriculture. Part of the uncleared area is still covered with dense forests, and part of it is cut-over land. Most of the unsettled area is as good for agricultural purposes, as that which has already been brought under the plow.

Land Values.—The land still unopened to agriculture, is held at various prices, varying from $8 to $15 per acre, the price depending on location, amount of merchantable timber, etc. Cleared land generally sells for $40 to $60 per acre, depending on the character of the farm buildings. As already described, the soil of this type and its surface features are quite variable, and nearly all farms are likely to contain some land of relatively low agricultural value with the land of very good character.

MILLTOWN LOAM.

Area.—The Milltown loam is mainly within Polk county, occurring in bodies of considerable extent in the region about Milltown, Centuria, and Sand Lake; farther east in the southern part of the town of Georgetown is a large body and also a considerable area in the region about Joel and Range; there is also a small body in the town of Farmington. The total area of this type is about 110 square miles.

Surface.—The surface varies from level to slightly undulating, containing depressions or basins, some of which are occupied by lakes, ponds, and small marshes. The topography is the characteristic "pitted plain" topography of glacial drift areas. The depressions and basins, however, occupy only a relatively small proportion of the tract, most of the land being nearly level to slightly rolling, see Plate IX.

Native Forest.—The soil was originally covered with dense hardwoods, with some pine and hemlock. The hardwoods were mainly, maple, birch, oak, elm and basswood. Some poplar and pine grew along the streams. The pine has been wholly cut and most of the hardwoods have been removed. Practically all of this land is set off into farms and probably 40 to 50 per cent of the land is now under cultivation.

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Soil.—The surface four to eight inches of this soil is generally a fine, sandy loam or loam, grayish to brownish in color. The subsoil is grayish yellow loam, quite similar in texture to the surface soil to a varying depth of one to three feet, at which depth much sand and gravel is often met with. The mechanical analysis shows this soil to consist largely of very fine sand and silt. In some places the soil is quite stony, the stone being glacial boulders mainly of granite rock. Like all other glacial soils in the area the type contains a variable amount of gravel in the soil, the gravel being more abundant in the subsoil than in the surface soil. The material of the drift consists wholly of granite and sandstone material mixed with silty clay, and sand. The subsoil conditions are favorable to good underdrainage and the surface soil is capable of holding sufficient soil moisture, for all crops, with the ordinary rainfall. The type is an easy one to cultivate, and on the whole is one of the most fertile soils in the region. It has already developed into one of the most thrifty agricultural sections of Polk county.

The results of mechanical analyses of a sample of the soil and subsoil is shown in the following table:

TABLE XXIX.—*Mechanical analysis of Milltown loam.*

No.	Locality.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
146	Polk Co.....	Soil.....	.0	7.7	9.9	14.2	23.9	36.0	8.0
146	Polk Co.....	Subsoil...	.0	9.9	12.8	17 4	22.0	24.7	13.2

Agriculture.—The Milltown loam is well adapted to diversified farming and is now quite generally devoted to dairying and grain raising. The leading grain is oats, with a much smaller acreage of barley, wheat, corn, and rye. The average yield of wheat is 18 to 22 bushels per acre, of oats 40 to 50 bushels, barley 35 to 40 bushels, and corn 30 to 35 bushels. The yield of hay is generally 1½ to 2 tons yer acre. The acreage to potatoes is relatively small, the usual yield being 100 to 150 bushels per acre.

Dairying is the leading industry on this type of soil as it is on all the soils throughout Polk county. The value of dairy

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products from the farm on this type is more than that of the grain crops raised.

Stock raising is also important, the principal stock sold from the farm being cattle and hogs, with sheep relatively unimportant.

The principal dairy product is creamery butter, though cheese is the principal product in the Farmington area. The cream is quite generally separated on the farm. Besides supplying local creameries, large shipments of cream and milk are sent to St. Paul and Minneapolis.

This soil type is well adapted to dairying. Silos are common and indicate a progressive dairy system. The grade of dairy stock is gradually being improved, but more attention should be paid to this subject, and more rapid improvements made. The improvement of dairy stock is very important and is well worth the closest attention by the farmer.

The practice of extensive dairying on this type has kept up the soil to a good grade of fertility as is shown by the good yields of grain.

Land Values.—The farm lands on this type are of good value. Unimproved land is generally held at $20 to $30 per acre. Improved land is usually held at $60 to $80 per acre. Most of the land of this type has already been divided into farms, though a large percentage of the farm area is still uncleared.

THORNAPPLE SANDY LOAM.

Area.—The Thornapple sandy loam is mainly within Rusk and Chippewa counties, the largest area mapped being in the town of Thornapple, Rusk county. It is typically developed on the so-called "Peninsula" between the Flambeau and Chippewa rivers. The boundaries fixed for this soil formation on the map are only approximate. Within these soil areas as mapped are several phases of sandy loams, but owing to the fact that large portions of this area are not well settled, exact boundaries could not be located with any degree of accuracy.

Surface Features.—While in a general way the surface of this soil is nearly level to undulating, there as areas which are hilly, having a sort of choppy appearance. The uneven tracts are characterized by small knob-like elevations and some depres-

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sions. Marshes and lakes are common features within the general area of this soil.

The surface of this soil was determined largely by the ice which moved over this tract. The erosion by streams thus far has not caused much change in the original topography left after the deposition of the glacial drift sheet.

Forest.—Most of this soil was originally covered with forest trees, consisting mainly of black oak, and white pine. Within the general area are ridges of heavier soil which developed good stands of hardwoods. The heavy pine timber has been cut, and aside from a few hard wood ridges yet remaining, the area is now mainly covered with a thicket of poplar, birch, small oak, and pin cherry. On the level areas where the soil is sandier, thick brush and sweet ferns are common.

Soil.—Both the surface soil and subsoil are sandy loam, consisting of a large proportion of fine to coarse sand and a small proportion of silt and clay. The surface soil to a depth of six or eight inches contains sufficient organic material to give it a medium dark to grayish color. The subsoil is light colored, grayish to yellowish, and consists mainly of sand with a little clay to a considerable depth.

The results of the mechanical analysis of the soil and subsoil are shown in the following table:

TABLE XV.—*Mechanical analysis of Thornapple sandy loam.*

No.	Location.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
164	Rusk Co.....	Soil.....	1.1	28.2	22.7	15.7	5.6	20.3	6.5
163	Rusk Co.....	Soil.....	.1	15.1	23.5	31.8	11.1	13.6	5.9
163	Rusk Co.....	Subsoil...	.4	13.6	23.3	33.8	10.1	14.6	4.6

There are slight variations from the general type. The level stretches along the rivers are nearly flat, mostly pine land, and the soil contains much coarse sand. Over the undulating areas, some stone occurs and there is a larger proportion of fine sand and silt in the soil, and hardwood forest mixed with the pine was developed.

Agriculture.—The soil is well adapted to dairying and to the raising of such grains as oats, buckwheat, and barley. Corn has been raised and matured successfully. The soil may be

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worked earlier in spring than the heavier soils and is not apt to be cold in spring months when corn wants a warm seed bed. There is, however, some danger from drought on sandy phases during dry season on account of porous nature of the soil.

Tobacco and potatoes are grown with good results. Clover hay yields plentifully. Alfalfa and mammoth clover should be grown on this soil. So far little has been attempted in the way of growing alfalfa and other special crops.

Only a small percentage of the area of this soil is now under cultivation. The farms already developed are in a thrifty condition and prove the soil well adapted to general agriculture with dairying and potato raising as the principal industries.

Land Values.—The open land is more easily cleared than the dense hardwood areas. The wild land is generally held at $10 to $20 per acre, and the cleared land generally from $40 to $60 per acre.

CUSHING LOAMS.

Area.—The Cushing loams lie in the western part of Polk and St. Croix counties. They lie wholly within the area of the undulating terminal moraines of the latest drift sheet.

Surface.—The surface of this soil is more or less hilly, with low hills associated with depressions, lakes and ponds. The topography is the characteristic terminal moraine topography, with abrupt basins and steeply sloping ridges. Surrounding many of the lakes, and also adjacent to streams are many small marshes, most of which are too small to be shown on the map.

Throughout the area, are many nearly level areas which are usually either quite sandy or quite clayey. Stone and boulders are more common in the uneven lands than over the level tracts, but some of the low and marshy tracts are also stony. The stones are not usually so abundant as to interfere seriously with agriculture.

Native Forest.—This soil was quite generally covered with a dense growth of hardwoods, pine, and hemlock. As elsewhere in this region, the pine has been wholly cut. The hardwoods and hemlock remain only in isolated tracts. The hardwoods were chiefly maple, oak, elm, birch, and basswood. On the lighter phases of the loam the white pine predominated, while on the heavier soil the hardwoods were most abundant.

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Soil.—The surface eight inches of this soil consists generally of a loam. From eight to twenty-four inches the subsoil becomes more clayey and also carries a larger content of gravelly material than the surface soil.

This soil, however, varies considerably both in the surface and subsurface layers. Some tracts contain a large percentage of medium and fine sand and are a sandy loam. These sandy areas are usually rolling though in some places adjoining stream bottoms the surface is more nearly level and also more sandy.

The soil is derived from the weathering of glacial drift in which limestone debris is generally an abundant constituent. This soil area therefore is confined to that part of the region containing limestone bearing drift, or is within the general area in which limestone is the prevailing underlying rock.

A large area of hilly, sandy loam occurs in the town of Somerset in St. Croix county and around Dresser Junction in Polk county.

Another variety of soil with a high content of clay and silt occurs in patches here and there within the tract mapped as Cushing loam. These areas are less undulating and somewhat stony in places but are generally well improved. In Polk county, southwest of Clayton, in Black Brook, and in Alden, south of Little Falls, are areas of these heavy loams. In the preliminary soil mapping done here neither the sandy nor the clayey phases of the loam have been separated from one another. To do so with any degree of accuracy would require a very detailed survey.

TABLE XVI.—*Mechanical analysis of Cushing loams.*

No.	Location.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
138	Polk Co.....	Soil.....	.0	5.1	4.7	16.0	11.2	62.5	10.4
138	Polk Co.....	Subsoil...	.1	5.7	5.4	6.4	18.9	45.5	17.8
142	Polk Co.....	Soil.....	.7	9.5	9.3	18.3	25.4	26.5	10.2
142	Polk Co.....	Subsoil...	.5	6.9	8.6	18.2	21.8	26.4	17.6
151	Polk Co.....	Soil.....	.1	12.6	15.4	16 2	10.7	35.8	8.9
151	Polk Co.....	Subsoil...	.0	13.2	12 9	14.2	13.4	31.3	14.4
127	St. Croix Co.....	Soil.....	.5	9.6	8.6	9.5	21.8	43.3	6.4
127	St. Croix Co.....	Subsoil...	.4	8.4	7.8	8.8	24.5	36.2	13.8

Agriculture.—The Cushing loams are well adapted to general agriculture. They are especially well adapted to dairying and stock raising. The summer rainfall is usually abundant and

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grains and hay do exceptionally well. Sheep raising is quite important in the towns of Alden and Black Brook. Dairying is now the leading industry and will probably increase in importance in the future. Clover, timothy, and alfalfa do exceptionally well for hay crops.

In portions of southeast Polk county hay is sold at present in large quantities from the farms. It is usually baled directly from the field or from stacks later in the season. This system of selling hay from the farm is not altogether commendable unless concentrated feed for stock is imported. The better way is to adapt the farm practice so that the hay and forage crops are fed directly on the farm and the dairy product and live stock sold. This system of farm management of course, would require more work and skill, but on the other hand, the fertility of the soil could be maintained and increased by the application of manure from the stock, and the value of the farms increased.

The distance from market should also be considered in adopting systems of farming. Long hauls over heavy roads has the tendency to reduce farm produce to as concentrated a form as possible. For this reason, many farmers' co-operative creameries have been established. In southern Polk fewer creameries have been organized than cheese factories.

Oats are the most important grain crop and the average yield is 35 to 45 bushels per acre. Wheat is grown quite extensively, the yield on the heavier loams with high content of limestone being 18 to 20 bushels per acre, while on the lighter sandy loams the average yield is about 15 bushels. Barley on the heavier limesstone soil generally yields about 30 to 35 bushels per acre, and on the lighter sandy soil from 25 to 30 bushels. The corn crop is about as abundant as wheat or barley, the usual yields being from 30 to 35 bushels per acre. In Farmington and Osceola considerable corn is grown for silage. The potato is also an important crop, the usual yield being about 100 bushels per acre. The yield of hay is about one and one-half tons per acre.

Land Values.—The area of this soil is fairly well settled and a relatively large proportion of the land, probably 25 to 35 per cent, is under cultivation. Uncleared land is generally held at $15 to $25 per acre, and cleared land at $50 to $80 per acre. Quite often, however, farms well located and in a high state of cultivation are sold for more than $80 per acre.

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RICE LAKE LOAM.

Area.—The Rice Lake loams are in bodies varying from five square miles to twenty square miles in extent, and are located in nearly all the counties of this area. The largest continuous tracts occur in the vicinity of Rice Lake and Barron in Barron county, and about Rusk in Dunn county. Another large area is in southwestern St. Croix county. East of Hudson this soil area is known as Hudson Prairie, north of Richmond as Star Prairie, near Chippewa Falls as Eagle Prairie and west of Eau Claire as Truax Prairie. Other small areas occur as indicated on the map. The total area includes about 328,000 acres.

Surface.—The soil is confined to the valleys, and is typical valley bottom land. The surface of this formation is uniformly level, with some portions quite flat. See Fig. 1, Plate X. Here and there small depressions may be found, some of which are occupied by small lakes. Some marshes and wet land are associated with this type, but the marshes are usually small and are not indicated on the map.

Forest.—In the area about Rice Lake in Barron county and about Eagleton in Chippewa county there was a rather dense growth of mixed hardwoods and pine. The hardwoods were mainly maple, oak, elm, and some basswood. Besides the white pine, there was some Norway pine and hemlock.

Farther west in Dunn and St. Croix counties, the native vegetation consisted largely of a light stand of scrub oak poplar, some birch and pine. In most cases the clearing of this thinly forested land was a comparatively easy matter for the early settlers.

Soil.—The Rice Lake loams vary from a fine sandy loam and loam to silt loam. Most of the soil, however, is a fine sandy loam or loam, and only in a small proportion of the area is silt loam. See Fig. 2, Plate X.

In general the surface eight inches is a loam carrying sufficient organic matter to produce a medium dark color. The subsoil is a sandy to silty loam to a depth of 1 to 3 feet, grading into gravel and sand. In places the gravel and sand subsoil lies very near the surface, less than a foot of loam overlying it. The surface soil also shows some variations, and grades from dark sandy loam to a brown, silty loam.

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Fig. 1. TOBACCO FIELD ON RICE LAKE LOAM, EAGLE PRAIRIE, CHIPPEWA COUNTY.

Fig. 2. SECTION OF RICE LAKE LOAM, NEAR CAMPIA, BARRON COUNTY. TYPE OF ALLUVIAL SOIL.

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This soil about Rice Lake and Barron, in Barron county, and in the area about Eagleton and Bloomer in Chippewa county, contains small areas of the heavier silt loam, but much the larger proportion in these localities is a fine sandy loam or loam. In eastern Eau Claire county in the valleys of Thompson's Creek, and Bear Grass Creek, silt loams predominate while in the valleys farther west fine sandy loams are the prevailing type. Silt loams also predominate in the small valleys on the west side of the Eau Galle river in the town of Eau Galle and Weston in Dunn county. Outside of the localities referred to, the soil mapped as this type is a fine sandy loam or loam.

The results of the mechanical analyses of the soil and subsoil are shown in the following table:

TABLE XVII.—*Mechanical analysis of Rice Lake loams.*

No.	Locality.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
6	Chippewa Co.....	Soil.....	.2	12.5	11.4	9.1	7.2	46.8	12.4
6	Chippewa Co.....	Subsoil...	.3	11.3	11.9	10.4	5.7	47.1	13.2
108	Dunn Co.....	Soil.....	.4	18.0	14.3	10.0	9.6	32.3	14.8
108	Dunn Co.....	Subsoil...	.4	11.9	14.3	12.1	16.4	29.8	15.1
124	St. Croix Co.....	Soil.....	.3	11.9	9.8	9.0	13.9	35.2	19.3
124	St. Croix Co.....	Subsoil...	.0	11.5	9.6	8.9	18.9	33.5	17.3
155	Barron Co.....	Soil.....	.3	20.6	14.9	9.1	4.0	36.3	14.2
155	Barron Co.....	Subsoil...	.2	20.1	14.7	11.3	8.8	28.7	15.4
157	Eau Claire Co....	Soil.....	.2	3.5	6.5	8.1	10.5	59.2	11.9
157	Eau Claire Co....	Subsoil...	.0	2.4	4.3	5.4	10.1	64.0	13.8

This soil is uniformly free from boulders, and practically all of it can be brought under cultivation. It is very largely under improvement in many of the areas. The dark sandy loams like that of Rusk Prairie and Hudson Prairie were easily brought under the plow and have long been under cultivation. The heavier phases of the soil do not contain a very high percentage of clay and are not sticky when wet and do not bake when dry. Where the land is nearly level some complaint is made on new land that the soil is cold in the spring, but this difficulty will probably be overcome after the land is cultivated more and the soil more thoroughly aerated. Some of the level tracts, however, will probably require tile drainage to bring them up to a proper state of fertility.

Chemical analyses of composite samples of the surface eight inches of the soil show it to be well supplied with potassium, with

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a fair amount of nitrogen, and with a fair amount of phosphorus.

Extreme acidity has developed on much of this soil in Dunn and St. Croix counties. From a large number of actual fertilizer tests of acid soils, it has been shown that soils in an acid condition require phosphate fertilizer to insure best results. The Wisconsin Experiment station carried on considerable experimental work with acid soils, and results are published in Bulletin No. 139, showing quite conclusively that corn growing in acid soils made more rapid growth and developed more fully when a fartilizer was added which contained phosphorus, either alone or in combination with potash or nitrogen, than when phosphate was omitted and the potash and nitrogen alone were added either singly or in combinations. The supply of nitrogen can be maintained by judicious seeding of clover and alfalfa crops. At the present time but little of the latter valuable legume is being raised. Red clover does well as a rule.

In a dairy country, where bran or other concentrated food stuffs are commonly purchased, and where the manure is carefully cared for and little loss incurred from barnyard leaching and in handling, the supply of phosphorus can be maintained. This has been found true in older dairy sections of the state. Where the purchase of feed stuffs is impracticable, the phosphorus supply can be increased for large crops by the purchase of this element in the form of commercial fertilizers, as explained elsewhere.

Agriculture.—This soil has developed into one of the best general farming soils of the region. The common grains are all grown to a variable extent with good average returns. In the western part of the region in Dunn, Polk, and St. Croix counties on the thinly forested or prairie tracts, this soil was cropped to grain, especially wheat, for many years. The grain yields, however, after a few years decreased, and 20 to 30 bushels of wheat per acre became the exception instead of the rule. The causes that led to the decrease in yield were partly due to soil condition, and partly to the chinch bug. The result was that other grains, such as barley, rye, oats, and corn were tried and a rotation practiced. Clover became a crop that occupied the land a portion of the time. Stock raising became more general, especially for dairy purposes and during the last 15 years a marked

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increase in dairy and live stock production has taken place. The census statistics show the increase in dairy products to have been very marked, during the last ten years through all the countries. On the whole this is a very desirable change as far as it concerns the maintenance of a good state of agriculture on this soil.

The present yield of wheat is about 12 to 18 bushels per acre, of oats 35 to 40 bushels, rye 12 to 15 bushels, of barley 30 to 35 bushels, and corn 25 to 35 bushels. The potato is usually an important crop, the avearge yield being 100 to 150 bushels per acre.

Special crops have developed to considerable extent north and northwest of River Falls, on the area northwest of Eau Claire known as Truax Prairie, and north of Chippewa on Eagle Prairie. The special crops are potatoes, tobacco, cabbage, canning peas, sweet corn, sugar beets, and small fruit. Peas for canning are extensively grown on this soil about Rice Lake, Campia, and Barron. An attractive market near by and soil adapted to such crops are doing much to increase the revenues from farming.

Where these special cultivated crops are grown to a large extent year after year, the rotation must include some crop that will replenish the organic matter which is removed by a system of special crops. Red clover or rye are excellent crops to plow down and allow to decay. The clover also serves the purpose of enriching the soil in nitrogen, one of the elements that special crops like peas and corn require in large amounts. The pea crop, although a leguminous crop, contributes but a small amount of nitrogen to the soil, its root system being very limited as compared to that of clover.

The location of these tracts near to towns of considerable size makes it possible to purchase manure from livery stables and elsewhere. Where this can be purchased at reasonable price it makes good fertilizing material although there is danger that fields so fertilized will become infested with noxious weeds. The system of farming, where such crops as peas are raised, is especially conducive to a rapid spread of weeds even where no manure from cities is applied. This is an added reason why rotation is desirable, involving clover and oats where these can be fed profitably to stock, either to sheep or to dairy cattle.

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This probably is the preferable method of maintaining soil fertility on these areas, where special crops are remunerative and adapted to the soil condition. Corn is grown extensively in the Farmington area and to some extent in other portions of Polk county. In Barron county corn has not been grown so extensively on this soil.

Fertilizer requirements become of much importance in some of these special crop areas. Tobacco, cabbage, and potatoes and sugar beets are heavy feeders of potassium and where these crops are raised in considerable quantities, fertilizers rich in potassium are needed. Potassium sulphate at the rate of 150 to 175 pounds per acre will be sufficient for the special crops grown. The better and more economical way for the farmer is to purchase fertilizers for his particular crop requirement rather than to buy the complete fertilizer already mixed by the manufacturer, as the latter fertilizer often contains elements with which the soil is already well supplied.

While all grains receive more or less attention, the dairy industry is rapidly becoming much more important than grain raising; and while some grain is sold from the farm, the leading exports are dairy products and live stock. On most of this soil, the dairy product is cream sent to the local creamery. Farmers usually separate the milk on the farm. In Farmington, the cheese factories make American cheese, while in Rice Lake and Turtle Lake, the manufacture of brick cheese is more important.

Land Values.—Farm values on this soil are relatively high, the soil in general being well adapted to agriculture. Wild land is probably held at $20 to $30 per acre. Improved lands are sold at $50 to $100 per acre, the average prices being from $70 to $90 per acre. Well organized dairy farms, and farms devoted partly to special crops, especially to peas, command the highest prices.

CHETEK SANDY LOAM.

Area.—The Chetek sandy loam is in irregular areas bordering some of the large rivers and streams. It occurs in small tracts in every county except Rusk and Polk, the largest tract being in Barron county. In the entire area it includes about 230,000 acres. As a general rule this soil is associated with

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VIEW OF CHETEK SANDY LOAM, NEAR ANSON, CHIPPEWA COUNTY.
Farm buildings and small groves of jack pine in the distance.

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areas of the Sterling sand. Along the Red Ceder river in Barron county the close association of these two soils is well illustrated.

Surface.—The surface of this soil formation is nearly level, similar to that of the Sterling sand; but the surface is not quite so level in general as that of the latter, more areas within this type being somewhat slightly rolling. See Plate XI. In a few places around Cameron and east of Chetek, the soil is somewhat stony.

Native Forest.—The forest growth was mainly Jack pine with some white and black oak. As a rule the stand of timber was fairly dense.

Soil.—The Chetek sandy loam is a medium sandy loam to depth of eight inches. The surface soil contains considerable coarse and medium sand and is fairly well supplied with organic matter, giving it a medium dark color. The subsoil contains less organic matter and more coarse sand and gravel material than the surface soil as a rule.

The results of the mechanical analyses of this soil and subsoil from Barron and Chippewa counties are shown in the following table:

Mechanical analyses of Chetek sandy loam.

No.	Locality.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
160	Barron Co.....	Soil.....	.1	25.5	23.6	16.5	2.0	22.6	9.1
160	Barron Co.....	Subsoil...	.2	25.4	24.2	16.7	2.8	18.5	9.6
10	Chippewa Co.....	Soil...	.2	28.1	22.0	14 6	2.9	21.2	11.0
10	Chippewa Co.....	Subsoil...	.4	20.7	23.4	16.8	2.6	28.7	7.4

Around Cameron and east of Chetek, small boulders are associated with the surface soil but not in sufficient number to interfere with cultivation. Around River Falls, in Pierce county, this type shows variations, to a sandy loam and to muck. These heavier soil bodies are usually too small to be separated on the general soil map. Some of this soil in the bottom lands is only a few feet deep to the bed rock.

Agriculture.—The principal crops grown on this soil are oats, rye, corn, potatoes, and hay. Corn can be relied upon to ripen on this soil in Barron county as it permits planting earlier in

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the spring than the heavier upland soils. The yield of oats is 25 to 35 bushels per acre, of corn 20 to 30 bushels. Potatoes are an important crop on this soil about Cameron and Chetek, the average yield being 100 to 150 bushels per acre. The yield of hay is generally from 1 to 1½ tons per acre.

The soil is well adapted to combination farming in which live-stock and dairying should be most important. In order to maintain the fertility of sand or sandy loam soil, the keeping of abundant stock on the farms is of more importance than on the heavier soils. Manure, if sufficient amounts can be obtained, has always been the best fertilizer for the farmer. Besides supplying fertilizing material, it improves the physical condition of the soil as no commercial fertilizer can. Where manure cannot be purchased from outside sources, the farmer should arrange his system of farming so as to include dairy cows and such other live stock as is best adapted to his farming conditions. If this is not feasible, commercial fertilizer may be needed.

Clover has been grown on this soil with good success, and ought to be a more general crop. This soil is quite acid or "sour" as a rule and may require application of ground limestone where difficulty is experiences in obtaining a catch of clover. (See pages 71–2.) Alfalfa will do well when once a stand is obtained. These leguminous crops should occupy the land one to two years during the four year rotation period. The supply of total nitrogen in this soil, similar to that of nearly every sandy soil, is below the average. The growing of clover is the cheapest method for the farmer to replenish his soil with this valuable plant food constituent.

Special crops, such as tobacco, cucumbers, sweet corn, and peas are being grown, successfully, on limited areas of this soil about Chetek and Chippewa Falls. Where good markets are conveniently located, this soil ought to pay well, for it is an excellent truck soil.

Land Values.—Most of the soil of this type has been divided up into farms for a number of years. Uncleared land is generally held at $10 to $20 per acre. Improved land in a fair state of cultivation is generally held at $30 to $60 per acre. The farms devoted to dairying and to the special crops, peas, corn, or tobacco, command the highest prices.

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MERIDEAN SANDY LOAM.

Area.—This soil mainly occupies the bottom lands lying along the lower Chippewa, Red Cedar, and Eau Galle rivers. The width of this bottom land varies from a narrow strip to a belt 1 mile to 2 miles wide. This soil is the lowest river bottom land and is about five to fifteen feet above the level of the river.

Surface.—The surface of this type is nearly level. Here and there are small undulating tracts. The shifting of the Chippewa river in places has cut off portions of its former river bed, thus forming small ponds in the abandoned river channel. Where marshes are found these are generally associated with cut-offs formed in this way.

Forest.—Practically all the forest growth has been removed from this soil. In scattered areas only are stands of elm, maple, ash and a few oak remaining. On the most sandy phases of this soil scrub oak and some pine were developed.

Soil.—The soil on these lower bottoms is usually sandy loam though it varies considerably. The surface eight inches contains considerable coarse and fine sand with small amount of clay material. The subsoil becomes sandier with more coarse and gravelly material. As a rule the surface soil carries a fair amount of organic matter and has a rather dark color.

While a large proportion of the river bottoms are light sandy loams, there are important areas of limited extent of heavier soil that differ markedly from the light sandy loam described above. This heavier soil is located along the Chippewa river in Dunn county in the vicinity of Caryville and Meridean, forming an area of about 15 to 20 square miles in all. Farther up the river in Eau Claire county in Secs. 4, 5, 8, 9, T. 26, R. 10, is another small tract. The surface eight inches on these more fertile areas is a fine sandy loam with some clayey material and high organic matter as evidenced by the dark color. The subsoil, eight to twenty-four inches, is made up of sandy soil lighter in color but also carrying a fairly high content of organic matter.

The results of the mechanical analyses of the heavier loam soil and subsoil are shown in the following table:

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TABLE XVIII.—*Mechanical analyses of Meridean sandy loam.*

No.	Locality.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
11	Eau Claire Co....	Soil.....	.5	18.2	23.7	24.4	9.6	13.7	9.7
11	Eau Claire Co....	Subsoil...	.1	16.5	23.9	26.1	10.0	14.6	8.5
112	Dunn Co..... ...	Soil.....	.0	12.5	17.2	20.7	17.8	23.3	8.2
112	Dunn Co..... ..	Subsoil...	.2	12.6	16.8	21.9	19.9	20.5	8.1

Crops.—The heavier phase of Meridean sandy loam is being devoted to general farming including dairying and some grain raising, chiefly oats. Tame hay yields well, and corn is one of the best crops grown. At Meridean many silos have been built and the dairy interests supports a thriving creamery at this point.

The heavy phase of this soil in Eau Claire county is devoted to special crops and found to be very profitable. The leading special crops grown, are cabbage, sugar beets, sweet corn, potatoes, cucumbers, and tomatoes. The yields of these crops during 1909 seemed to warrant more extensive development. The question of the best means of fertilizing is very important in connection with the raising of special crops. Stable manure from Eau Claire has been shipped in and used by farmers on this soil. This is the best all-around fertilizer, but for certain crops, like cabbage and potatoes which require much potassium it will be more economical to buy this particular element in a commercial fertilizer. A commercial phosphate fertilizer also may be better than manure in some cases.

All the soil along the bottoms was found to be acid, indicating a general need of lime either as ground limestone or air-slaked lime. Clover can be raised on this type with good results and should be maintained in the rotation of crops.

On the sandy phase of this bottom soil mixed farming is conducted. The grains are mainly oats, rye, and some buckwheat. Potatoes and corn yield well. Some of this soil, however, is practically non-agricultural, due to the poor physical condition of the soil resulting from lack of drainage. For example a large part of the wet and marshy bottom land from Meridean to Durand on both sides of the Chippewa river is at present of little value agriculturally.

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Land values.—The farm values along the river bottoms are quite variable. Most of this land is held at $25 to $50 per acre. However, farms on which dairying, stock-raising or truck raising are the leading features command prices from $50 to $100 per acre.

Sterling Sand.

Area.—The Sterling sand is typically developed in the central and western parts of the town of Sterling in northwestern Polk county. This locality is often referred to as "Sterling Prairie" because of its level surface and the general absence of forest trees.

This sandy soil area in the town of Sterling is a part of the large belt of so-called "barrens" or "plains" which is mainly confined to the vicinity of the St. Croix river and its tributaries, particularly the Nemakagon, Totogatig, Yellow, and Clam rivers. As outlined in a general way by Strong[1] this sandy plain is a linear tract having an average width of 12 to 15 miles, stretching from a point about 12 miles from the Bayfield peninsula nearly due southwest to the mouth of Wolf Creek in Polk county, a distance of 125 miles. This tract is joined by a tapering belt on the east lying along the Nemakagon river.

Besides the area of sandy soil in the town of Sterling, which is a part of the so-called "barrens" there are quite similar sandy soils within the area described in this report which may be conveniently classed with this type. The largest and most prominent of these areas is the large tract of sandy soil along the Eau Claire river in Eau Claire county. Other smaller areas, as indicated on the soil map, are along some of the small streams in southern Eau Claire county, and in eastern Pepin county. There is also a considerable area of this type north of the Chippewa river in the town of Spring Brook, Dunn county, and another along the Mississippi river in the vicinity of Pepin and Hager.

Surface.—The surface of this type of soil is uniformly nearly level. In many places, however, the nearly level surface is broken by the occurrence of ridges of wind blown sand, "sand dunes," and in other places by narrow valleys cut by streams and by small sags or depressions left by glacial action. In

[1] Geol. of Wis. Vol. III, p. 386.

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places this type of soil is closey associated with marshes and wet sandy land.

Native Vegetation.—This type of soil was originally only sparsely covered with forest trees. Considerable areas were practically free from timber, while other areas were covered with a light growth of jack-pine, aspen, and occasionally Norway pine. Other areas were covered with burr oak, black oak, and white oak brush with occasional trees of these species. The common "brake" and "sweet fern" are usually present on this soil.

Groundwater Conditions.—The depth to the level of ground water in this sandy soil is variable. In the town of Sterling in northwestern Polk, the wells are generally from 20 to 40 feet deep. In eastern Eau Claire county the ground water level is generally quite near the surface, except immediately adjacent to the Eau Claire river. In many places in eastern Eau Claire the general water level is only from 10 to 15 feet below the surface and where this condition prevails the agricultural possibilities of the soil is enhanced. Along the Chippewa and Mississippi rivers the water level is generally from 40 to 80 feet below the surface.

The lack of forest growth on this soil is largely determined, very probably, by lack of moisture in the subsoil.

Soil.—The Sterling sand in its typical development consists mainly of medium sand somewhat brownish and dark at the surface, grading down to lighter colored sand. In places a gravelly subsoil is struck at depth of two or three feet, but generally the subsoil is medium to coarse sand to a considerable depth. The mechanical analyses of representative samples of this soil from various localities are shown in the following table:

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TABLE XIX.—*Mechanical analyses of Sterling sand.*

No.	Locality.	Description.	Fine gravel	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
145	Polk Co., T. 36, R. 19.....	Soil.....	.0	5.9	22.4	46.5	15.7	4.9	4.2
145	Polk Co., T. 36, R. 19.....	Subsoil...	.3	7.2	26.5	46.2	12.5	3.7	3.7
15	Eau Claire Co., T. 26, R. 6	Soil.....	1.1	12.4	13.5	44.0	17.4	7.8	4.6
15	Eau Claire Co., T. 26, R. 6.	Subsoil...	.0	17.1	14.1	43.1	18.1	4.3	3.3
106	Dunn Co., T. 27, R. 11.....	Soil.....	.3	20.8	24.8	33.6	5.7	7.0	6.9
106	Dunn Co., T. 27, R. 11.....	Subsoil...	.4	22.5	28.6	31.1	5.5	6.2	6.1
117	Pepin Co., T. 25, R. 13, 14	Soil.....	.7	15.4	27.7	34.5	9.2	7.8	5.0
117	Pepin Co., T. 25, R. 13, 14	Subsoil...	.6	14.2	24.9	37.3	9.0	7.3	6.0

The mechanical analyses of these samples from the several counties, are very similar to one another and are almost identical with the analysis of the Plainfield sand type of the U. S. Bureau of Soils classification. The Sterling sand is approximately the same type of soil as the Wisconsin river sandy soil described in the soil report of North Central Wisconsin.*

The nitrogen and organic matter in the Sterling sand are relatively low, the chemical analysis showing about one-half the amount of these constituents in this type as occur in the loams and silt loams of the area. There is, however, a considerable variation from place to place in the amount of organic matter. Some of this soil in Pepin county contains considerable dark organic material in the surface three or four inches of soil. On the other hand along the Eau Claire river in eastern Eau Claire county there is a large area characterized by its nearly white color, indicative of only a small amount of organic material in the surface soil.

From the limited number of chemical analyses which have been made thus far it appears that these sandy soils are fairly well supplied with potassium while the supply of phosphorus is considerably less than in loam soils.

Besides the smaller amounts of plant food in the sandy soils, which in many cases is in forms not available to plants, the lower grade of fertility of the soil type is due to the porous

* Bull. 11 Wis. Survey, p. 17–20.

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texture of the soil, causing excessive leaching of soluble plant food, and to its incapacity to retain sufficient soil moisture for crop use during critical stages of plant growth.

The Sterling sand, not alone along the Eau Claire river and along other rivers of the southern part of the area but also in the town of Sterling and the associated tract of "sand plains" or "barrens" of the upper St. Croix river and tributaries is a typical alluvial sand formation deposited by rivers.

Red lacustrine clays were observed along the St. Croix river just north of Nevers' dam, and at the mouth of Wolf Creek. In the continuation of the Sterling sand belt in Burnett county red lacustrine clays were observed about Grantsburg beneath the sand formation. Similar red calcarecus lacustrine clays were observed in some of the valleys of Eau Claire county. These lacustrine clays are essentially similar in character and origin to the red clays along Lake Michigan and Lake Superior, although these interior deposits are likely to contain a larger proportion of sand and silt than the clays occurring adjacent to the Great Lakes.

Wherever these lacustrine red clays are associated with the sands and come near enough to the surface to contribute material to the surface soils and influence soil moisture phases of loams are developed having a higher grade of fertility than the uniformly deep sand soils.

Agriculuture.—This sandy alluvial soil, on account of its open porous character is subject to leaching of soluble plant food, and the rapid oxidation of organic matter. As a type it is probably the most infertile soil of the state. It is the only soil within this area in which abandoned farms have been observed. However, this soil type in other parts of the state and also within this area is being farmed with fair yields of crops under proper management.

The principal grain crops grown on this soil are oats, rye, and corn. The yield per acre is variable depending entirely on proper management of the soil. Where the state of fertility of the soil is maintained nearly as good average yields are obtained as on the loam soils. Special crops, such as sweet corn, potatoes, and beans are well adopted to this soil type. The potato is an especially good crop, and yields of 100 to 150 bushels per acre are common. The bean is quite extensively grown on this

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type of soil in certain parts of Michigan and the acreage of this crop should be increased in this region.

Dairying may be carried on profitably in conjunction with the special and grain crops mentioned above. Where dairying is practised the principal forage crops are clover and corn, the latter often used as silage. Alfalfa can also be grown on this soil under proper soil conditions.

Land Values.—The land values on this soil type are quite variable, depending largely on the conditions under which the farms are managed. Wild land is generally held at $5 to $10 per acre. Land under cultivation is generally held at $10 to $30 per acre with some farms under the very best management often selling above $30 per acre.

Management of Sandy Soils.—The management* of sandy soils presents some of the most difficult problems confronting the farmer today and it is doubtful whether some of the abandoned farms on this soil will be reclaimed until the difference in cost of more productive soils of the state is greater than it is at present. Just as soon as the heavier loam soils are all taken, and values reach $100 or more per acre, the light sandy soils will be again brought under cultivation and made to produce such crops as are adapted to sandy soils. This is the condition at present in the older parts of this state and also abroad where large tracts of abandoned lands of sandy nature have been made productive under proper management.

As already stated sandy soils are difficult to manage. In a fertilizer test on this soil a complete fertilizer produces the best results. Potash, however, in sufficient amounts is usually found in this area as shown by chemical analyses.

The first step in the improvement of sandy soil is to increase the organic matter. Besides supplying nitrogen the water-holding capacity of the soil is increased by incorporation of vegetable matter. For this purpose clover is the best crop that the farmer can grow. This introduces a difficulty at once, for, as many farmers can well testify, to secure a catch is not an easy matter. Sandy soils are quite generally acid, and it has been found that clover prefers non-acid soils. Again, the season may be too dry or the soil may be exhausted by long pre-

* For a more complete discussion of the improvement of sandy soils, see Bulletin 204, Wis. Exp. Station, Madison, Wis.

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vious cropping, so that an application of barnyard manure or commercial fertilizer is needed to give the young clover plant a start until it can appropriate nitrogen from the air. Where soil shows acidity, an application of ground limestone at the rate of one ton per acre will be found beneficial. Air-slacked lime, marl or lime refuse from sugar beet factories are equally efficient.

This ground limestone may be added after the field is ready for planting, seeding to oats or rye being preferable, at the rate of six pecks per acre, and seeded with mammoth clover at the rate of 10 quarts per acre. If manure can be obtained it would help greatly to insure a stand if applied before seeding to grain at the rate of about four loads per acre. Should the season come off dry, it may be advisable to cut the grain green for hay in order to afford better moisture conditions for the clover seeding.

If a stand is obtained, the first crop may be cut for hay and second crop either be plowed under or allowed to go to seed. If this second crop is plowed under an application of 1000 pounds of ground rock phosphate per acre should be made. After the clover should follow a cultivated crop of corn or potatoes. This cultivated crop is followed by grain again and seeded with clover as before.

If conditions warrant the clover may be allowed to stand until the second year before being plowed under, thus making a four year rotation. At the beginning of this building up process, the three year rotation will perhaps be preferable.

After this heavy phosphate application, the amount added may be reduced and about one-fourth as much added once during a four year period. This system has been found successful by the State Experiment Station on sandy soils similar to this type. Farmers should not expect too much at the start, especially if the soil has been cropped continuously for many years and little manure added.

These soils are well adapted to clovers, and alfalfa will also thrive. Some fine fields of red clover were observed on the light sandy soil along the Red Cedar river in Dunn county. The clover was grown for seed in this section and was one of the principal sources of income from the farms. Dairying was carried on in connection, and manure, applied systematically. The land in the area was cropped to grains and other crops about

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VIEW OF HARTLAND SILT LOAM, NEAR ELLSWORTH, PIERCE COUNTY.
A characteristic view of the loess-covered uplands over the limestone.

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one-half the time, the remainder of the time given over to clover and pasture. It is needless to say that abandoned farms were not conspicuous in this locality.

An experimental farm on light sandy soil at Spooner, Washburn county, was recently started by the State Experimental Station. An experimental farm on similar sand in Marinette county also has recently been organized. Practical results in the management of sandy soil will be worked out and reported as early as possible.

Hartland Silt Loam (Loess).

Area.—The Hartland silt loam is principally in Pierce, Pepin and Dunn counties. The largest continuous area of this soil type forms a broad tract including nearly three-fourths of Pierce, more than one-half of Pepin and a long belt extending northward through the western townships of Dunn county. In Chippewa county there is an area of over a township located in Tilden, northwest of Chippewa Falls. There is a small area of the loess soil type about Ludington in Eau Claire county. South of a line between Augusta and Fall Creek is the most extensive tract in Eau Claire county, embracing about two townships. The total area of this soil is about 556,000 acres.

Surface Features.—The surface features of this formation are rolling or undulating, to hilly. See Plate XII. The surface inequalities are due chiefly to erosion of the underlying rock and the topography is often spoken of as an erosion or stream topography. No uniformity exists over any large area. For example adjacent to rivers or intermittent streams are areas ranging in width from one-half to three-fourths of a mile, which are likely to include considerable land that is rough and broken. This is especially the condition where the main rivers have eroded deep beds as is the case with most of the streams in Pierce and Pepin counties. Most of these deep channeled streams have developed extensive systems of short tributaries, nearly at right angles to the main stream and leading abruptly up to the adjacent uplands. These tributaries or feeders are dry runs except during rains or melting of the snow. In Chippewa and Eau Claire counties the streams channels are not as deep as those in Pierce, Pepin, and parts of Dunn, and consequently fewer of the extremely undulating areas are found.

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Forests—Over a broad belt reaching from the vicinity of Prescott and extending along the south border of Pierce and Pepin an area of hard woods, mainly of oak was originally developed. The stand was usually light and was referred to as "burr oak openings" by early settlers. At present no forest area of any extent remains on this tract except on the slopes or bottom lands. Similar forests of oak grew over the area northwest of Chippewa Falls, and in southeast Eau Claire county. In the remaining areas mixed hardwoods consisting of maple, oak, elm, and bass wood developed. Considerable pine and hemlock was associated with the hardwoods in southwest Dunn county and in eastern Chippewa county.

At the present time the timber products of this soil area are of little importance as compared with the agricultural products. In the town of Weston, Dunn county, there is a tract of 7500 acres of hardwood forest and a large saw mill is operated in that locality.

Soil.—The soil is a silt loam of medium dark buff color to a depth of six to eight inches. It is remarkably free from pebbles or stone, and possesses a characteristic smooth powdery feel. The mechanical analyses show that this soil is made up very largely of silt (grains whose diameters range between .05 to .005 mm); the clay content is usually low. The mechanical condition of the soil affects its physical properties profoundly. It can withstand heavy rainfall better than the heavier compact clay soils and does not bake or pack after rains.

The soil on account of its porous nature is subject to leaching of its soluble plant food. On similar soils in Iowa large tracts were rendered infertile on account of the rapid decomposition of its organic matter, but as yet there appears no danger from this source here. Chemical analyses show an average high content of organic matter. The subsoil, below eight inches, is buff to yellow in color and remarkably uniform in structure. The clay content is somewhat higher in the subsoil than in the surface soil. Like the surface soil the subsoil contains no coarse material.

The depth of the loess subsoil varies in the different areas. In Pierce and Pepin county the average depth is six to eight feet with some upland tracts much deeper. In eastern Chippewa this soil does not show the same degree of uniformity found in

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Fig. 1. SECTION OF AUBURN LOAM.
Type of residual soil on shaly sandstone. Near Menomonie, Dunn County.

Fig. 2. SECTION OF HARTLAND SILT LOAM.
Shows two to four feet of loess overlying shaly sandstone. On upland southeast of Chippewa Falls.

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the other areas. As a rule it is not as deep either. This soil in Pierce, Pepin and western Dunn counties is generally underlain by limestone, and in the other counties by sandstone. The relation of the loess soil to the underlying sandstone is illustrated in fig. 2, Plate XIII.

The results of the mechanical analyses of the soil and subsoil are shown in the following table:

TABLE XX.—*Mechanical analyses of Hartland silt loam* (Loess).

No.	Locality.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
118	Pepin Co.....	Soil.....	.0	.9	.7	3.3	18.7	65.1	11.5
118	Pepin Co.....	Subsoil...	.0	.2	.3	2.1	27.8	56.5	13.0
9	Chippewa Co.....	Soil.....	.1	1.3	1.4	2.2	22.1	62.1	10.1
9	Chippewa Co....	Subsoil...	.0	.1	.2	.5	7.3	78.7	12.9
113	Dunn Co.....	Soil.....	.4	1.6	1.4	7.2	27.5	51.8	9.9
113	Dunn Co.....	Subsoil...	.0	.6	.5	2.0	32.1	53.9	10.4

The origin of this silty loam explains in a measure its uniformity. This soil is "loess," and was deposited by wind carrying fine material from unprotected areas farther west. The loess soils are widespread over large portions of the Mississippi valley.

On account of the uniform silty composition of this soil type and its rolling character it is particularly susceptible to side hill erosion. The loss from this source may be considerable, depending on the slope and the kind of crop raised. Usually where ordinary care is taken destructive gullying can be prevented, although many areas were observed that were badly cut up into large and small ditches.

In general when the slope is steep it should remain in hay or meadow land most of the time, only plowing it up in order to reseed again. The crops raised also influence the liability of erosion. Areas planted to potatoes and corn are subject to most erosion. The best system to follow in farming the slopes is to crop with oats, wheat or barley, in rotation with clover. The slopes should remain in hay or meadow about two years out of a four or five year rotation—preferably two years out of four. Keeping the runways of water in sod has worked fairly satisfactory in some cases. On sloping clay soil in the southern states, furrows dug along at right angles to slope "terracing" have been found an efficient and cheap means of lessening slope

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erosion. These furrows are placed at intervals of about 100 feet and connect with an outlet ditch down the slope at one end of the field. The system so constructed is maintained permanently though it offers some inconvenience in the use of farm machinery.

Tiling similar uplands has been found advantageous, in reducing the loss from erosion. In sloping soils tile laid in the direction of slope six to eight rods apart increased the water holdng capacity and decreased the surface run-off very materially.

Agriculture.—This soil type is especially well adapted to grain raising and to general farming in which dairy products are the important exports from the farm. Both these systems are being carried on on this soil type. Grain raising is confined principally to the so-called "prairie" tracts, the largest area of which extends along the southern border of Pierce and in Pepin counties. The grains raised are mainly oats and barley; less wheat is raised now than 15 years ago when this section was well known as a wheat growing area.

The areas originally forested with hardwoods have adopted combination farming, and here dairy products are in the lead. The grains, oats, barley and corn are raised and yield well, but do not form an appreciable portion of the exports.

These two systems of farming differ radically in their influence on keeping up the fertility of the soil. The grain farmer in the past has not concerned himself very much with principles of soil fertility, not alone in this area but in all grain raising sections of the country. Up to about 1890 the grain section of this soil type was devoted to wheat. No attempt at rotation was made and clover was grown in only limited areas. A shrinkage in yield and partial loss of crops in the early nineties resulted in less wheat being grown, and brought about a rotation involving the growing of a variety of grains such as oats, barley and some wheat. Clover also was more generally grown. This system is practiced now and the leading grains are oats and barley; more live stock is being kept and the stock furnishes needed fertilizer. Farmers, however, depend largely on clovers to enrich their soils and as a proof of increased fertility point to the fine yields now obtained. While clover is important, it adds but one of the plant food elements essential to crops, namely the element

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VIEW OF HARTLAND SILT LOAM, NEAR MENOMONIE, DUNN COUNTY.
Shows an area of very thin loess over the shaly sandstone.

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nitrogen. Besides supplying nitrogen, however, the clover also adds organic matter to the soil, and also improves the physical condition of the soil by its deep root system, permitting air and water to enter the soil more thoroughly.

But while clover adds nitrogen and organic material to the soil, it removes large amounts of phosphorus like the grain crops. Barn yard manure, where it is available, adds phosphorus as well as nitrogen to the soil. But even where the manure is obtained from forage and grain crops grown on the farm, the supply of phosphorus is not increased but rather decreased due to the loss by leaching and otherwise in handling the manure.

The grain farmer may, therefore, find it advisable to apply phosphorus to the soil which has been subjected to excessive or continuous cropping. The cheapest form in which to supply phosphorus is by application of the ground rock phosphate as explained in another place. An application of 800 to 1000 pounds per acre to begin with and a light application of about 250 pounds per acre thereafter, during each rotation period will usually be sufficient. Clover should occupy the land two years during a four or five year rotation with oats, barley or wheat.

The farmer who practices combination farming, in which live stock, dairy cows, fat stock, hogs, and sheep are kept, usually sells no grain from the farm and in addition usually purchases concentrated feed stuffs, such as bran which is high in phosphorus content. The supply of nitrogen in the soil can be maintained by growing of leguminous crops, such as clover. Potassium is an abundant element in this soil type as the chemical analyses of a large number of soils indicates.

A larger acreage of this soil type in Pierce and Pepin is devoted to barley than to oats, barley being the leading grain in these two counties. In the other counties, the oats are the principal grain raised on this soil. In Pierce and Pepin the average yield of barley is 30 to 35 bushels per acre. In the other counties the yield is about 30 bushels, with the exception of the town of Lincoln in Eau Claire where 35 bushels is the average yield.

The average yield of wheat is 15 to 18 bushels per acre, and of oats about 40 bushels per acre. The acreage of rye in some localities is equal to that of wheat, with an average yield of 15 to 20 bushels per acre. The acreage of corn on this soil is less than that of barley or oats in Pierce and Pepin and less than

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oats and more than barley in Dunn, Chippewa and Eau Claire. The yield of corn per acre is generally from 30 to 35 bushels. Clover and timothy are the main crops for forage. In a few areas alfalfa has been tried. This soil is admirably adapted to alfalfa, and it ought to be more generally grown.

Special Crops.—Similar silt loam soils have been found admirably adapted to fruit culture in other states. In this area considerable fruit is now being grown, especially apples and some plums. The hill sides where erosion is troublesome are well adapted to fruit trees and grape vines. The fruit culture ought to be encouraged and more care given to the trees by spraying and pruning when needed.

Land Values.—This type of soil is one of the most fertile in the entire region. Farm values therefore are relatively high, as they are elsewhere on the loess soils throughout the Mississippi Valley. With few exceptions this soil has been laid out in farms for many years. Uncleared land, with little or no merchantable timber, is generally held at $20 to $40 per acre. Cleared land is generally held at $60 to $100 per acre. Farms on which dairying is the principle industry, as in Cook's Valley, Chippewa county, command higher prices than farms which have been devoted mainly to grain raising.

AUBURN LOAM.

Area.—The Auburn loam lies in Chippewa, Eau Claire, Dunn and Barron counties. The soil of the town of Auburn, Chippewa county, is mainly of this type, hence the name. The boundaries of the various bodies are very irregular, as shown on the map. Many of these bodies are small, but often they are extensive, as for example the area southeast of Menomonie, in Dunn county, a tract nearly two townships in extent and the large area in northwestern Chippewa county and in southeastern Barron county. Around Elk Mound is another large area, and in Eau Claire county are also a number of areas of considerable extent.

Surface.—The Auburn loam is characterized by a hilly and undulating surface, becoming in places quite rough and the slopes quite steep. The topography is characteristic stream erosion topography developed on sandstone and shale formations. Not all the area is hilly and undulating. The surface is

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VIEW OF AUBURN LOAM, SOUTHWEST OF EAU CLAIRE.
Shows the characteristic valleys and even uplands of this type of soil area.

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more gently roling in the area south of Elk Mound. In other places similar uplands with gentle slopes are found but more often sharply undulating and hilly features prevail. The surface features are illustrated in Plates XIV and XV.

Forest.—The area was originally wooded with hardwoods, mainly red oak, black oak, burr oak, some birch, poplar and scattering maple. At present considerable wooded tracts remain made up chiefly of black oak, and poplar. More of the steeply sloping areas of this soil type ought to remain in forest These slope areas are well adapted to tree growth and when covered with forest would prevent destructive gullying so noticeable on many of the fields which lie on the slopes.

Soil.—The surface eight inches of this soil varies from a loam to a silt loam containing considerable silt. The surface soil is buff to yellowish in color and contains a medium amount of organic matter. The subsoil to depth of 24 inches is usually a sandy to clayey loam. At three to three and one-half feet the soil in many cases become quite sandy. Shale and sand rock outcrops are common along road cuts and in many places there are only a few inches of soil overlying the sandstone formation. The sandstone and overlying soil is illustrated in figure 1, Plate XIII.

The Auburn loam has been formed largely from the weathering of shaley sandstone of the Potsdam (Middle Cambrian) formation. The shale contains much coarse sand and a large proportion of clayey material. Although the area of this soil has been glaciated by the earliest glaciers, only a very small contribution of drift was added to the soil. The soil is a typical residual soil and is the only one of this class within the area. While the general soil type is a loam, there are considerable areas in which the soil becomes quite sandy. The more sandy soils are usually in the areas where the underlying rock is a nearly pure sandstone, without any shale and the soil is the direct result of weathered pure sandstone. North of Wheeler in Dunn county some especially sandy areas are found. Likewise in the eastern part of Eau Claire county there are isolated areas of very sandy uplands.

The results of the mechanical analyses of the soil and subsoil from various parts of the area are shown in the following table:

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TABLE XXI.—*Mechanical analyses of the Auburn loam.*

No.	Locality.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
158	Barron Co.....	Soil.....	.1	3.3	5.9	11.6	9.6	57.1	11.9
158	Barron Co.....	Subsoil...	.0	4.1	6.4	15.3	15.4	39.6	19.0
12	Eau Claire Co...	Soil.....	.2	6.9	11.1	13.1	14.9	42.7	10.5
12	Eau Claire Co...	Subsoil...	.0	5.3	9.6	14.4	15.1	43.0	12.5
110	Dunn Co.....	Soil.....	.5	15.0	18.0	17.6	12.9	26.6	9.7
110	Dunn Co.....	Subsoil...	.5	14.3	17.3	19.0	18.9	21.1	9.3

Somewhat heavier soils as well as lighter, more sandy soils than those analyzed in the table occur within the area. But the variation in the general texture of the soil is fairly well illustrated by the samples analyzed.

Soil Erosion.—The character of this soil with regard to its topography affords conditions favorable to side hill erosion. It is difficult to estimate the annual loss by erosion, either from loss in fertility by removal of fine soil particles or in consequence of gullying of the fields where the slopes are cultivated. As above stated as far as possible the steep slopes should remain in forest. If the steep slopes are already cleared the cultivated crops should not be planted oftener than once in three or four years, and the slopes should be allowed to remain in hay meadows or pasture the remainder of the time. Farmers thus far have not apparently appreciated the loss from erosion, otherwise more precaution would have been exercised to prevent it.

Agriculture.—A highly developed system of diversified farming is practiced on this soil type. Abundant pasture lands and a soil well adapted to cereals and corn make this area one especialy well suited for general farming.

The usual grains are oats, barley, wheat and some rye. Oats, however, are the leading grain, the average yield being 35 bushels per acre. Corn is an important crop, especially in Dunn county. It matures early and yields 40 to 50 bushels per acre.

Clover and timothy are the usual hay crops, the average yield being one to two tons per acre. Alfalfa has not been introduced extensively as yet but where farmers have planted small fields it has been found to give splendid results. It will probably be more extensively grown on this soil when its value as a forage crop is realized. The potato crop is generally important on the sandy loam, the yields being 100 to 150 bushels per acre.

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Dairy products together with live stock, hogs, beef, etc., are the leading exports from the farm. Cream is shipped to local creameries operated on a co-operative basis by the farmers. Very little grain is sold from the farm, but is fed on the farm and sold as manufactured dairy and live stock product. The tendency at present is toward keeping more pure-blooded animals, of dairy type as a rule; breeders' organizations are aiding materially in the movement to eliminate the scrub cow from the farm.

Besides the general system of farming to which this soil is well adapted, the production of fruit ought to receive more attention. The loamy soil is splendidly adapted for raising apples and other tree fruits. The steep hillsides may be brought to produce abundantly when planted to fruit trees and grapevines, provided proper attention be given. At the present time little has been attempted in this way. The Auburn loam, except where the very sandy phases predominate is one of the most productive soils of northwestern Wisconsin. Crop yields have been fairly well maintained and only few farms showed soil in poor condition. Acidity of the soil has not developed to a large extent.

The supply of nitrogen can be maintained by the growing of leguminous crops, clover and alfalfa. This is the cheapest source of obtaining the most expensive constituent of plant food. With regard to phosphorus farmers have already in few instances expended $4 to $4.50 per acre for rock phosphate fertilizer. Where concentrated food stuffs for stock is not brought onto the farm from outside sources the application of mineral phosphate is a good method of maintaining the soil with high phosphorus content.

Land Values.—Practically all this soil type is now laid out into farms though less than one-half is cleared land. Uncleared land is generally held at $15 to $30 per acre, and cleared land from $50 to $80, with occasional higher prices where farms are well situated and in a good state of improvement.

PEAT AND MUCK. (Marshland.)

Area.—While marshy tracts of more or less limited extent occur in all of the counties five of the counties contain a larger proportion of marsh than the others. These are Chippewa, Rusk,

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Barron, Dunn and Eau Claire. In Chippewa and Rusk are areas occupying four to five thousand acres in one continuous marsh tract. In Barron, Dunn and Eau Claire counties many small areas adjacent to streams or in bottom lands are wet and marshy. In Polk many small tracts of marshy areas occur over the entire county.

Surface.—The surface of these marshes is nearly level, the level surface being primarily the cause of its being a marsh. But while the areas appear to have almost a level surface, upon more careful observation a fall, sufficient for drainage can usually be obtained.

Native Vegetation.—Over many marsh areas a stand of tamarack, some cedar, and willows are found, while in others only marsh grass thrives. Moss is a common growth acquiring a depth of several feet in some cases. The peat in the marshes consists of an accumulation of moss and marsh grass, and varies widely in depth. In Dunn and southern Chippewa and Eau Claire the depth ranges from two to four feet, and is underlain by sandy subsoil. Along the Lamb Creek in Dunn county four to five feet of peat were often measured before the sandy lower soil was reached. In Rusk county large areas where the peat measured about three feet before clay soil was reached were common.

Oftentimes lakes and ponds are included within marshy land, making it more difficult of drainage unless sufficient fall and outlet can be secured.

Of the marsh lands of the entire area, a conservative estimate would be about five to six per cent. In Pierce and St. Croix counties less than one per cent of the total area is marsh land. The amount of marsh land in some of the townships in eastern Rusk, and northeastern Chippewa where marsh and swamp land is most abundant is probably from 20 to 25 per cent of the township. Other townships in Rusk and Chippewa counties have less than one per cent of marsh land.

The agricultural value of these marsh areas is dependant entirely upon their reclamation. At the present time undrained and unimproved the larger proportion of marsh land is only of incidental value and then only for wild hay as a rule. In the management of these marshes the first requisite is proper drainage to remove surplus water and thus fit the area for cultivation.

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Before taking up the question of crops and fertilizer requirement the subject of drainage will be discussed. The following discussion is abstracted from a recent bulletin* of the Wisconsin Experiment Station.

Drainage of Marsh Lands. *Deep outlet ditches.* The construction of deep outlet ditches is the first step in the reclamation of broad marsh areas, particularly the peat marshes. Such marshes usually receive the run-off from upland areas several times their size. Covered drains of the required capacity would be very expensive.

The minimum depth of outlet ditches should be five feet, except where opportunities for self cleaning are good, when the depth may be decreased to four feet. The bottom width should be at least one-half of the depth. Eight feet is perhaps the most advisable depth on marshes more than half a mile wide. On marshes less than half a mile wide or where the transverse slope to the ditch is more than a foot in eighty rods, the depth may be reduced. Here also the bottom width should be at least one-half the depth and as much more as the requirements seem to demand. It must be remembered that it is the depth to which a ditch will empty itself and not the depth to which it is dug that determines its efficiency.

Usually the outlet ditch is not made too deep, but it is often made too wide. One ditch that has been observed was made four feet deep and sixteen feet wide, because the dredge used could not make a narrower ditch. The result was that during the normal summer flow, a stream about two feet wide shifted from one side to the other on the wide bottom. The remainder of the bottom grew up with rank weeds, which, collecting sediment during high water, is gradually filling up the ditch. A ditch with a four foot bottom and six feet deep would be more serviceable and durable. Dredge men unskilled at handling the dipper frequently find it easier to make the slopes almost vertical. This should not be tolerated because with such slopes the banks are almost certain to fall in and to accumulate on the bottom of the ditch. A ditch six feet wide at the bottom, six feet deep and eighteen feet wide at the top (6x6x18) is more permanent than a ditch of the same depth and eighteen feet wide at

* "Principles and Practice of Land Drainage," by E. R. Jones, Bulletin No. 199, Wis. Exp. Station.

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the bottom and top. With a small effort the slopes of the former ditch can be made smooth and sodded over to prevent erosion and growth of rank weeds.

Shallow Surface Ditches.—Shallow surface ditches are those intended only to conduct surface water to deep ditches or to natural outlets. Since they are of use only during flood flow, they are dry most of the time and they may be called "dry" ditches.

Forms and Size.—Except where a cutting has to be made through a ridge they seldom need to be more than two feet deep. With rounded bottoms and a top width of ten or twelve feet the slopes are such as to admit of crossing with teams, vehicles, and implements. Where the slopes and bottom are sodded, the appearance is improved and the grass growing in them may be mowed for hay. Shallow ditches along permanent fences, where they will be out of the way of cultivation may be made narrower and with steeper side slopes.

All that has been claimed for deep outlet ditches is that they are the first step in the reclamation of a humus marsh. They stand ready to carry off the water brought to them, but are slow to reach out after water. The logical way of developing a humus marsh is as follows: Co-operate with your neighbors in organizing a drainage district and put in a deep outlet ditch. Then along forty lines or property lines put in shallow surface ditches one foot deep at the head and perhaps three feet deep where they empty in the deep ditch. Then plow the adjacent fields in narrow lands so that there will be dead furrows every four rods leading into the shallow ditches. Such a net work of surface drains with a deep ditch for an outlet will afford sufficient drainage to raise timothy hay on the area. When it seems advisable to put in covered underdrains, other crops may be raised. Small ditches with dikes on the side toward the marsh are frequently used to protect marshes from flood water. The dike may be made of the earth excavated.

Cost.—The construction of the vast majority of deep outlet ditches requires the use of steam or gasoline dredges. The cost of hauling a dredge from the railroad station to the marsh, and that of putting it together and tearing it apart is the same whether the ditch be long or short. Large contracts are frequently taken for seven cents a cubic yard. The rate for small

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contracts is sometimes twice that figure. At ten cents a yard a 6x7x20 ditch costs about $1,700 a mile. Peat can be handled for less money than either sand or clay.

The cost of shallow ditches can be materially decreased if a dry time is chosen for their construction. Where team and scraper or a road grader can be used, a depression two feet deep and ten or twelve feet wide at the top can be made for thirty cents a rod.

Causes of Failure.—It is evident, that three of the causes of failure in the reclamation of humus marshes are: (1) shallow ditches have been put in without first providing a deep ditch for an outlet; (2) deep ditches have been put in without afterwards putting in shallow ditches for feeders; and (3) some well drained marshes have been poorly managed.

Deep and shallow ditches should be given an opportunity to work hand in hand. Neither is complete without the other. Land owners who have expended five dollars an acre for a deep outlet ditch, lose a large part of its value by refusing to expend two dollars an acre more upon surface ditches for feeders, or a greater amount for tile where deeper and more permanent drainage is desired.

Crops.—Having properly provided for removal of surplus water by suitable drainage system as outlined above, the question of crops adapted and fertilizer requirement is in order. It may be stated at the outset that the marsh tracts of this section differ in some respects from similar tracts in adjoining states. Some of the peat here is not so well decomposed—not so muck-like,—and not so deep as those of neighboring states. The crops to which Wisconsin marshes are adapted likewise differ. Of course the location being further north, likewise exerts an influence on plant growth not always given due weight.

The best crop thus far tried on Wisconsin marshes for the first year or two is buckwheat. The marsh is plowed to a depth of 6 inches or so and disked up and seeded to buckwheat at a rate of 1 bushel per acre. After first or second crop of buckwheat the field may be seeded to alsike and timothy or red top and if a system of farming is followed that requires much hay the marsh land can very profitably be devoted to that purpose. It will, of course, be necessary occasionally to turn up the sod and seed to some grain crop to establish new growth of seeding

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again. Yields of two tons of hay per acre are not uncommon when this type of land has been properly managed and cared for.

If grain crops are desirable, barley has been found preferable, and also corn where climate is favorable. Oats was found to do wonderfully well in some areas. Trucking crops, such as potatoes and cabbage, have proved successfull as well.

To maintain maximum yields addition of fertilizing material is essential. Practically all the marsh lands with possible exception of those in Polk county are sour or in an acid condition. They also require both phosphoric acid and potash fertilizer. Wood ashes where these can be obtained in unleached condition, are a cheap and excellent fertilizer to supply the potash. They may be applied at rate of one ton per acre and should be harrowed in thoroughly. When wood ashes are not available the imported potash fertilizer should be used.

To supply the phosphorus* needed the ground rock phosphate is preferable, although ground bonemeal also gives good satisfaction where tried. The ground rock phosphate may be added in the fall of the year at the rate of one-half ton per acre for the first application, and smaller amounts later. If the bonemeal is used, 300 pounds per acre are sufficient. Application of phosphate need not be repeated for three or four years.

The additional supply of nitrogen fertilizers has shown no marked improvement in crop yield. The peat marshes with their large supply of organic matter usually afford more than enough nitrogen in a form available to plants. Wherever barn yard manure is available on the farm it can be added with profit. Where this is done, purchase of commercial fertilizers is unnecessary. As a rule, however, it is best to use the manure on the ordinary soils of the farm where a complete fertilizer is needed, and to apply a special mineral fertilizer of phosphate and potash to the muck soils.

In the Newer Portion.—With cut over land in the northern part of the state selling for about fifteen dollars an acre, the greatest factor in determining the value of cleared land is the cost of removing the stumps, slashings and stones. Assuming

* For a more complete discussion of the management of marshland soils, see Bull. 205, which may be had on application to the College of Agriculture, Madison, Wis.

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this to vary from ten to forty dollars an acre, the total cost of cleared upland ready for the plow is from twenty-five to over fifty dollars an acre. Open peat marshes, those containing no wood or brush, can be bought for from three to five dollars an acre. For ten dollars an acre with a combination of deep and shallow ditches they can be drained to a degree that will permit the growth of timothy hay. They can be plowed immediately after drainage at a cost not greater than that of breaking upland. Assuming farther that the fertilizer requirement of the marsh soil can be supplied for a few years at least very cheaply in the form of wood ashes from the saw mills or from the burned brush piles of the upland, the settler in northern Wisconsin can make tame hay land out of peat marshes for less than half the average cost of doing the same with upland. It is probable, however, that for the production of the cereals, it is better for the present to clear upland, than to attempt the more complete drainage of the humus marshes that would be necessary for this purpose.

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CHAPTER IV.

AGRICULTURE.

HISTORICAL.

This area like other portions of central and northern Wisconsin, was originally covered with much hardwood and pine, the latter being especially abundant on the sandy lands along the rivers. Only in the western part of the area, mainly in St. Croix county, thinly wooded and prairie lands occur. It was the pine lumber industry that first attracted the permanent settlers to the area. The location of saw mills around which villages and cities were built were the centers from which the agricultural development later proceeded.

The pioneer lumbermen came in from the south, up the Mississippi river and its main tributaries, the Chippewa and the St. Croix. Before the railroads penetrated the area the logs and sawed lumber were floated or towed down the river in rafts. To a certain extent this mode of transportation is still used, though the more rapid shipment by rail is now the usual method.

For a number of years lumbering was the leading industry of the area. For the last 15 or 20 years, however, agriculture has been in the lead and is steadily growing in importance.

First Settlements.—Long before the first permanent settlements were made in this area the region had been visited by explorers and fur traders. Father Hennepin visited the Sioux Indians at St. Croix Falls as early as 1681. "Fort Beau Harnais" trading post was built on Lake Pepin in 1793. Jonathan Carver went up the Chippewa river as far as Chippewa Falls in 1767.

The first permanent settlement in the area was made in 1828 when a saw mill was erected at the mouth of Wilson Creek, the present site of Menomonie. As early as 1839 three mills were in operation in the vicinity of Menomonie. St. Croix Falls was first

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settled in 1837, and Chippewa Falls in 1839. A saw mill at Eau Galle was built in 1840. A saw mill was built at Osceola in 1842 and a grist mill in 1848. Hudson was first settled in 1840 and the first farm opened there in 1841. Eau Claire was first settled in 1845. Settlers located in the vicinity of Pepin in 1846, at River Falls in 1848, and at Arkansaw in 1852. The first logging in Barron county was carried on in 1848 and the first farm opened in the southern part of the county in 1855.

Early Transportation.—Before the advent of the railroads, steam boats ascended the Chippewa river as far as Eau Claire, and ascended the St. Croix river as far as St. Croix Falls. River traffic on the Chippewa was abandoned soon after the railroads reached Eau Claire, but river traffic is still important between Stillwater and Hudson and various ports on the Mississippi. Occasionally excursion boats go beyond Stillwater to St. Croix Falls.

The first railroad, now the C. St. P. M. & O. R., reached the area in 1870. The present C. St. P. M. & O. R R. railroad connection between Chippewa Falls and Eau Claire was made in 1875, and the Wisconsin Central, now the "Soo" line reached Chippewa Falls from Abbotsford in 1880. The railroad was built from Eau Claire to St. Paul in 1871–2.

Population.—The growth in population in the nine counties of the area since 1860 is shown in the following table:

TABLE XXII.—*Population of the area from 1860 to 1910* (U. S. Census).

County.	1860	1870	1880	1890	1900	1910
Chippewa	1,895	8,311	15,491	25,143	33,037	32,103
Eau Claire	3,162	1',769	19,993	30,673	31,692	32,721
Dunn	2,704	9,488	16,817	22,664	25,043	25,260
Pepin	2,892	4,659	6,226	6,932	7,905	7,577
Pierce	4,672	9,958	17,744	20,385	23,943	22,079
St. Croix	5,392	11,035	18,956	23,139	26,530	25 910
Polk	1,400	3,422	10,018	12,968	17,801	21 367
Barron	13	538	7,024	15,416	23,677	29,114
Rusk*	.....	.....	.....	.....	.....	11,160
	21,630	58,180	112,269	157,320	189,928	207,291

*Rusk county was organized from Chippewa county in 1901.

The table shows an increase of population for the entire area from 21,630 in 1860 to 207,291 in 1910. From 1860 to 1890 the increase in population was due to the development of lumbering as well as agriculture. Since 1890 the increase is largely

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due to the steady growth in agricultural population. The rural population of the southern and well settled counties, Eau Claire, Dunn, Pepin, Pierce, and St. Croix has remained about stationary since 1900. The northern unsettled counties, such as northern Chippewa, Rusk, Barron, and Polk show a steady increase.

Nativity of Population.—Most of the population of the several counties is native born. The following table compiled from the state census of 1905 shows the source of the population:

TABLE XXIII.—*Nativity of population, state census, 1905.*

County.	Total population.	Native born.	Germany.	Norway.	Sweden.	Denmark.	Canada.	Ireland.
Barron	28,376	21,225	1,226	2,648	911	205	713	67
Chippewa	32,000	24,862	2,200	1,766	233	122	1,633	251
Dunn	26,074	20,570	1,857	2,509	219	108	306	99
Eau Claire	33,519	25,893	2,609	2,847	280	99	938	253
Pepin	7,569	6,182	249	54	578	.....	121	29
Pierce	23,433	18,851	872	1,364	1,152	224	251	203
Polk	20,885	15,035	547	1,397	2,126	1,141	346	52
St. Croix	26,716	20,640	1,024	2,208	536	347	602	556
Rusk	9,748	7,824	328	343	226	69	484	17

The population is largely native born. The lowest percentage of native born is in Polk county, and the highest percentage is in Rusk, Pepin and Pierce. A large portion of the native born, however, from one-third to two-thirds, is of comparatively recent foreign parentage. The table shows that in all the counties except Chippewa the most important foreign element is Scandinavian. Of the Scandinavian element, the Norwegian predominates except in Polk county where the Swedes are more prominent. In Chippewa county the Germans are the most important foreign element, with Norwegians second, and French Canadians third. The Canadian element, mainly French Canadian is also important in Eau Claire, Barron, St. Croix and Rusk. The Danes are important in Polk, and there are numerous Irish in St. Croix.

General Conditions of Agricultural Development.—Certain parts of the area in Pepin, Pierce, Dunn and Eau Claire counties, are well settled, the earliest farm settlement dating back 50 to 60 years. Other parts, especially in the northern portion in Polk, Barron, Rusk and Chippewa, though having in general equally as good soils, are still covered with large areas of dense hardwood forests. The soil map of the area showing the distri-

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bution of wagon roads, expresses fairly well the distribution of the well settled and the very thinly settled parts of the area.

Proportion of Cultivated and Uncultivated Lands.—The following table gives the total land area in each county and also the amount of land under cultivation in 1885, 1895 and 1905. The percentage of total land under cultivation, according to census of 1905 is also given:

TABLE XXIV.—*Cultivated land.*

Counties.	Total land areas in 1000 acres.	Cultivated land in 1885 1000 acres.	Cultivated land in 1895 1000 acres.	Cultivated land in 1905 1000 acres.	Percentage of total land under cultivation 1905.
Barron	561	43	79	136	24.2
Chippewa	654	91	131	169	25.9
Dunn	540	136	175	218	40.4
Eau Claire	396	111	142	166	41.9
Pepin	152	45	54	62	40.9
Pierce	347	135	158	189	51.6
Polk	597	63	83	124	20.8
St. Croix	455	207	228	252	55.5
Rusk*	583	.....	.....	16	2.8

*Rusk, a part of Chippewa county until 1901.

This table shows the steady growth of agriculture in all the counties of the area. The county showing the greatest improvement between 1895 and 1905 is Barron, with Dunn second and Polk third. St. Croix county has the largest percentage of land under cultivation with Pierce second and Eau Claire third. Rusk county, only recently set off from northern Chippewa has only a small percentage of its area under cultivation.

Farm Buildings. Occasionally log houses are built in the newest settlements, but usually the farm homes are the ordinary type of frame structures. In all the better settled areas, new frame houses much more pretentious than those first built, have been constructed. Houses of brick have been built in many localities, but are not abundant. A very large number of the barns are of the stone basement type. Silos are not abundant but are gradually being built as the interest in dairying increases.

Price of Farm Lands. The value of cleared lands varies considerably in the area depending upon character of soil and also the general location. The best class of farm land is generally

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held at from 50 to 80 dollars per acre. Some lands, however, are held as high as 100 dollars per acre. Much of the lightest sand land is held at 20 to 40 dollars per acre. Good farm lands without improvements and with little or no merchantable timber, generally vary at present (1910) from 8 to 20 dollars per acre, the price depending upon accessibility by rail and wagon road, as well as upon character of the soil.

Crops. All the important common crops are grown in the areas. The following table shows the production of the important grain crops in 1904 from the latest available statistics.

TABLE XXII.—*Table showing acreage and production of grain in 1904.*

County.	Barley.		Buckwheat.		Corn.		Oats.		Rye.		Wheat.	
	A	B	A	B	A	B	A	B	A	B	A	B
Barron	3,502	91,893	1,114	17,380	3,242	76,959	31,574	1,145,025	1,245	22,706	3,073	51,542
Chippewa	1,952	54,427	959	16,390	10,792	264,732	42,584	1,742,098	1,913	28,114	2,177	33,542
Dunn	4,674	124,218	1,812	26,391	26,203	777,206	57,992	1,953,278	4,805	57,111	3,862	59,636
Eau Claire	4,152	131,063	2,510	34,885	14,854	386,861	47,609	1,688,520	5,427	66,942	4,556	64,106
Pepin	8,924	279,321	258	3,041	9,746	298,204	13,489	499,215	2,198	24,257	1,810	27,627
Pierce	35,023	1,075,79-	158	2,270	15,873	497,307	49,138	1,973,673	4,789	85,035	4,847	80,538
Polk	4,024	120,654	201	3,629	6,622	143,338	36,626	1,391,050	1,235	19,787	3,120	58,914
St. Croix	15,753	447,883	662	10,165	14,148	318,781	93,163	3,270,522	5,465	93,356	3,354	51,591
Rusk	151	4,974	115	1,852	275	7,749	1,308	46,573	51	896	73	1,560

The most important grain crop in the area, in acreage and bushels is the oat crop. From one to three million bushels were grown in each of the counties except Pepin and Rusk. St. Croix is one of the leading counties in the state in the production of oats, usually ranking among the first two or three counties. The acreage and production of oats in 1904 was approximately double that of 10 years earlier.

The next crop in importance is corn. Dunn county leads in the production of corn with Pierce second and Eau Claire third. The increase in the production of corn has not been important in the past 10 years.

Barley is next in importance in the area though wheat is more important than barley in many of the counties. Pierce county leads in barley, producing over one million bushels in 1904, almost as much as the entire remainder of the area. Pierce is one of the leading counties of the state in barley. There has been a considerable increase in production of barley

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in the past 10 or 11 years. St. Croix is second in barley and Pepin third in the area.

The wheat crop is relatively unimportant in the area at present though from 20 to 40 years ago it was the leading grain. At present Pierce leads in wheat, with Eau Claire second and Dunn third. At an earlier period St. Croix was the leading wheat county and was very important in wheat raising. There has been a steady decline in wheat raising in all the counties of the area since 1885. In 1885 St. Croix raised 1,807,985 bushels of wheat and in 1905 only 51,591.

Rye and buckwheat are relatively unimportant crops. The production of rye like that of barley has greatly increased in the area.

The potato is an important crop in Chippewa, Barron and Dunn counties. In these three counties the production has nearly doubled in the past 10 or 15 years. On the other hand the production in the other counties except in Eau Claire, shows a decrease. The potato is grown mainly on the sandy loam soils of the area.

TABLE XXIII.—*Acreage and production of potatoes 1885–1905.*

County.	1885.		1895.		1905.	
	Acres.	Bushels.	Acres.	Bushels.	Acres.	Bushels.
Barron	760	86,443	3,164	151,002	5,962	614,336
Chippewa	1,298	153,409	3,810	161,782	6,179	779,509
Dunn	1,344	144,373	3,898	159,486	5,474	602,678
Eau Claire	1,108	133,630	2,495	124,040	2,538	367,465
Pepin	440	42,773	592	21,631	351	43,276
Pierce	1,098	137,726	2,266	115,327	1,369	162,154
Polk	875	103,772	3,092	107,818	23,30	192,679
St. Croix	1,581	180,022	3,643	142,303	1,701	164,632
Rusk	.....	.....	.....	.....	501	55,995

Among the special crops, sugar beets, tobacco, pease and corn for canning are grown in various parts of the area. Tobacco is grown on the sandy loam soil in the vicinity of Chippewa Falls and Colfax and in various other localities in Chippewa, Barron and Dunn counties. Sugar beets are grown in Chippewa county, and to some extent in Eau Claire and Barron, the crop being worked up in the large sugar factory at Chippewa Falls. Pea canning factories are located at Chippewa Falls, Barron

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and Rice Lake and a considerable acreage in pease for canning has been developed in these localities.

Hay. The hay crop is an important one and has more than doubled in acreage and tons in the last 10 year period. The table shows the statistics for the census years of 1895, 1900 and 1905. St. Croix has the largest acreage in hay with Barron county second and Chippewa third. Barron county, however, raised the largest number of tons.

TABLE XXIV—*Acreage and production of hay.*

County.	1895. Hay.		U. S. Census 1900 (1899). Wild.		Clover.		Other tame grasses.		1905. Hay.	
	Acres.	Tons.	Acres.	Tons.	Acres.	Tons.	Acres.	Tons.	Acres.	Tons.
Barron	.....	21,349	2,513	2,781	861	1,175	42,847	51,096	53,808	80,920
Chippewa	.....	28,826	2,798	3,445	3,791	5,149	44,913	52,561	51,391	77,865
Dunn	.....	35,709	3,390	3,902	3,639	5,028	39,570	47,009	49,587	76,045
Eau Claire	.....	30,628	5,752	7,327	4,079	5,927	26,033	31,149	39,178	58,126
Pepin	.....	9,304	740	931	1,656	2,462	7,737	10,218	10,083	16,351
Pierce	.....	32,561	1,293	1,376	3,514	5,811	30,226	42,204	34,763	58,747
Polk	.....	24,104	4,645	5,350	1,074	1,697	32,065	39,438	47,854	69,501
St. Croix	.....	34,182	2,680	3,026	1,960	2,646	53,924	58,538	59,274	77,347
Rusk	.....	.....	.....	.....	.....	.....	.....	.....	7,756	12,447
	.....	216,663	23,811	28,138	20,574	29,995	277,315	332,213	353,694	527,359

The table shows that the production of hay increased nearly 4 times in the past decade in Barron county; nearly three times in Polk and Chippewa, and about two times in the other counties. The increase in the production of hay follow closely the increased development of the dairy industry in the several counties of the area. In the statistics compiled from the U. S. Census of 1900 it is interesting to note the tonnage of wild hay and of clover. Clover is an especially valuable crop grown in rotation with grains, in order to supply nitrogen to the soil. Eau Claire leads in the acreage of clover, with Chippewa second and Dunn third. The grain raising counties, especially St. Croix and Pepin do not make a good showing with regard to clover. In all the counties an increase in the acreage of clover ought to be made.

Dairying. Dairying is an important industry in all the counties of the area. The value of dairy products exceeds that of

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total grain in Barron, Rusk and Polk. In Chippewa the total value of grain is slightly greater than that of dairy products, and in the remaining counties grain considerably exceeds the value of dairy products. The value of the oat crop alone greatly exceeds the value of dairy products in St. Croix, and the oat crop or barley crop alone are almost equal to the dairy products in Polk, Pierce and Pepin counties.

In all the counties, however, there has been a great increase in dairying in recent years. The number of milch cows, and also the product and value has more than doubled in the last ten year period. The greatest increase is shown by Barron, with Polk, second, Chippewa third and Dunn fourth, as shown in the accompanying table.

TABLE XXV.—*Table of dairy statistics.*

County.	1895.		1905.	
	Milch cows.	Value of dairy products.	Milch cows.	Value of dairy products.
Barron	5,795	$74,584	17,767	$549,476
Chippewa	7,143	122,958	17,417	552,192
Dunn	9,758	142,600	20,944	624,435
Eau Claire	8,115	139,776	14,270	449,987
Pepin	3,275	44,963	5,371	165,664
Pierce	9,421	177,057	16,383	516,508
Polk	7,988	108,495	19,893	585,252
St. Croix	10,540	138,579	18,977	695,008
Rusk	.....	.....	2,329	143,136

The statistics in regard to amount and value of dairy products for 1895 are sufficiently complete for purposes of comparison with 1905. The increase in dairying, however, is best shown by the increase in number of milch cows between 1895 and 1905 in the various counties. While dairying will steadily increase in importance over the entire area in the future, it is quite likely that the greatest increase will take place in the northern and eastern counties where the soil conditions for grain raising are not so favorable as in the southwestern part of the area. Dairying, however, should be encouraged and developed as rapidly as possible in the southwestern counties as an important means of maintaining the fertility of the soil in connection with the extensive grain raising.

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Live Stock. Live Stock such as hogs, cattle and sheep is an important source of farm revenue. The value of live stock sold in 1904 is shown by the following table:

TABLE XXV.—*Value of live stock sold and consumed, and value of wool, in 1904 State Census, 1905.*

Counties.	Cattle and calves.	Hogs.	Sheep.	Wool.
Barron	$149,574	$87,963	$19,700	$13,803
Chippewa	127,633	128 288	8,496	9,937
Dunn	158,599	278,385	20,425	22,272
Eau Claire	84,685	149,622	6,016	5,989
Pepin	37,616	124,299	5,583	7,650
Pierce	211,541	194,837	47,505	49,570
Polk	170,964	104,923	8,993	8,548
St. Croix	213,946	159,301	21,145	21,783
Rusk	22,264	9,880	1,647	1,355
	1,176,822	1,222,538	139,570	140,907

From the table it may be seen that the annual revenue from the sale of hogs only slightly exceeds that of cattle in the area. The most important county for hogs is Dunn, and for cattle is Pierce. Pepin county ranks highest in hogs in proportion to the size of the county. Sheep and wool is not important as compared with other live stock. Pierce is the leading county in sheep, the value of sheep and wool sold in 1904 being $97,075 more than double that of any other county, and amounting to more than one third of the entire area. Pierce also usually ranks among the first two or three counties in the state in sheep and wool.

In addition to the crops already mentioned all kinds of garden truck are grown, and also an abundance of the common small fruits such as the strawberry, raspberry, blackberry, currant and gooseberry. Of the tree fruits the hardy varieties of the apple and the plum are grown successfully.

Transportation and Communication. Each of the counties of the area is well supplied with railroads, and telephone lines, and rural mail routes. In the well settled parts of the area good roads prevail, and in the thinly settled parts graded roads are built to new settlers as needed. In the vicinity of Eau Claire, some of the sandy roads have been greatly improved by the use of shale.

Markets. The leading cities with their population in 1910 are as follows:

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TABLE XXVI.—POPULATION OF CITIES OF THE AREA.

Eau Claire	18,310	New Richmond	1,988
Chippewa Falls	8,893	Durand	1,503
Menomonie	5,036	Barron	1,449
Rice Lake	3,968	Cumberland	1,445
Hudson	2,810	Bloomer	1,204
Stanley	2,675	Ellsworth	1,005
Ladysmith	2,352	Spring Valley	972
River Falls	1,991	Prescott	936

Smaller cities and villages are distributed over the entire area and afford ample means for trade.

Forest Conditions.—The valuable standing timber at the present time is in the northern and northeastern part of the area. Most of the pine forest was removed from 20 to 40 years ago, and very little or no pine is now left. Hardwood and hemlock forests of merchantable lumber, however, are abundant in Rusk, northeastern Chippewa and in the northern parts of Barron and Polk. There are some small tracts of good hardwood timber still remaining also in the eastern part of Pierce, southwestern part of Dunn and in the northeastern part of St. Croix. The hardwoods consist mainly of oak, maple, birch, basswood and ash.

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APPENDIX.

CORRELATION OF SOILS OF NORTH WESTERN WISCONSIN AND OF NORTH CENTRAL WISCONSIN.

The area of North Central Wisconsin, a preliminary soil survey of which was completed in 1903, lies immediately east of North Western Wisconsin along the eastern boundary of Eau Claire, Chippewa and Rusk counties.

In each of the areas, 14 soil types are distinguished and shown on the maps of the respective areas. While the number of soils mapped in the two areas is the same, the soils in the two areas differ in many respects.

The soils in the two areas are unlike on account of certain differences in the geological formations. The North Central area is very largely a region of granitic rock, with no limestone formations and no loess deposits. The North Western area on the other hand contains considerable areas of limestone and loess and while it also contains some areas of granitic rock, no typical residual soils on granitic rock are developed. Both areas, however, are alike in being covered with glacial drift and alluvial deposits.

Three soil types developed on the glacial drift, the Colby silt loam, the Chelsea loam, and the Kennan silt loam, are common types in both areas. The Marathon loam and the Mosinee gravelly soil, residual soils on the crystalline and granitic rocks, occur only in the North Central area. The Hartland silt loam, loess soil, and the Cushing loam and Baldwin silt loam, developed on limestone or limestone drift, occur only in the North West area.

Three phases of alluvial or bottom land soils are mapped in each area. Of the alluvial soils, the Rice Lake loam corresponds closely to the Antigo loam, the Chetek sandy loam corresponds closely to the Bancroft sandy loam, and the sterling sand cor-

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responds closely to the Wisconsin River sand. The Meridean sandy loam, the type on the lowest terrace of the alluvial bottom, is not mapped separately in the North Central area.

The Auburn loam, residual soil developed on the sandstone, is an important soil in the North West area and corresponds only in a general way to the Mentor sand and Cary sandy loam of Clark and Wood counties. The Mentor sand and Cary sandy loam consists of both upland and bottom land soils while the Auburn loam is a type of upland soil, on sandstone and shale associated with loess deposits.

The Milltown silt loam of Polk county has no closely corresponding type in the North Central area. The Thornapple sandy loam in Chippewa County, and the Harrison sandy soil in Lincoln county, and Amherst sandy loam in Portage and Marathon are phases of drift soils.

Three of the soil types on the glacial drift, the Kennan silt loam, the Chelsea loam, and the Colby silt loam extend across, as mapped, from the North Central area into the North Western area. Owing to the fact that eastern Chippewa county is fairly well opened up to farming at present while the western part of Taylor county was wholly unsettled at the time of the survey of the latter, the separation of the Kennan silt loam from the Chelsea loam in eastern Chippewa county has been made with greater detail than it was in Taylor county. The Kennan loam in Taylor county extends farther south, including a considerable larger portion of the region about Gilman than is shown on the soil map of North Central Wisconsin. In the next edition of the soil map it will be possible to make a more detailed survey of the soils in western Taylor county.

Owing to the fact that loess is of general occurrence over the sandstone of Eau Claire county, as well as to the fact that the sandstone itself contains much shale or clay, the soils of Eau Claire county differ considerably from those on the sandstone of western Clark county where these deposits are not developed. Both the sandstone upland soils and the bottom land soils in Eau Claire county as well as other parts of the North Western area are mapped with much greater detail and on a somewhat different basis than the soils of western Clark county. In general the Mentor sand of western Clark county corresponds

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closely with the Sterling sand, the former, however, contains sandy uplands as well as sandy bottoms, whereas the latter type includes only the sandy bottom soil. The Carey sandy loam of Clark county corresponds closely to the Auburn loam of Eau Claire in character of soil, though the former includes bottom lands as well as uplands, whereas the Auburn loam includes only the upland soils.

The Auburn loam type associated with occasional deposits of loess soil extends over a small area about Humbird on the western border of Clark county. In the next edition of the soil map of North Central Wisconsin a more detailed classification of the soil in western Clark should be made.

The various names of the soils in both the North Central and the North Western areas are of local derivation and are applied only provisionally with the plan in mind that probably other names will be used for these soils at some future time when a detailed survey of the soils of the entire state is completed. The soil names used in the U. S. Bureau of soils classification in the detailed surveys of the southern counties of the state will probably supercede many of the names used in the reconnoissance surveys of the northern parts of the state.

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